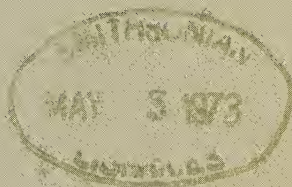






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THE BUTTERFLIES OF NEBRASKA

KURT JOHNSON¹

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CONTENTS

Introduction	5
Review of Literature	5
Methods and Procedures	7
Acknowledgments	8
Annotated List	9
Satyridae	9
Danaiidae	12
Libytheidae	22
Lycaenidae	22
Pieridae	28
Papilionidae	32
Hesperiidae	34
Megathymidae	40
Summary and Conclusions	41
Checklist	49
Figures	55

THE BUTTERFLIES OF NEBRASKA

KURT JOHNSON

INTRODUCTION

THE BUTTERFLIES OF NEBRASKA

Relatively few books or even lists of the butterflies of specific states are presently in existence. Of those which concern the Great Plains states, Field's (1938) study of Kansas butterflies is perhaps the best known and most complete. Leussler's (1938-39) brief annotated list of Nebraska butterflies and Truman's (1896) list of South Dakota Rhopalocera are less familiar to lepidopterists. Because of the increased usefulness of such studies to students of distribution and taxonomy, I initiated an eventual ten-year study of the distribution and taxonomy of the butterflies of Nebraska.

It is my purpose to provide a comprehensive account of the occurrence and some aspects of the biology of the butterflies of Nebraska. The depth of detail should make it beneficial to both amateur and professional lepidopterists, as well as other entomologists interested in butterflies.

REVIEW OF LITERATURE

Most of the research on Nebraska butterflies can be attributed to a few collectors. The earliest studies were in the late 1800's by staff of the University of Nebraska. At the turn of the century several expeditions were sent by the University throughout the state to collect many types of biological specimens. The published information on butterflies is summarized below.

W. L. Carpenter (1880) published a list of a few species of butterflies taken at Fort Niobrara, in Cherry County. H. G. Barber (1894) followed with a short and briefly annotated list of the butterfly specimens in the University collection. Most of these specimens are still in the State Museum at the University. Merritt Cary (1901), who had accompanied two University expeditions to the Pine Ridge in western Nebraska, published a list of butterflies found in Sioux County canyons. Cary (*loc. cit.*) listed nearly one hundred species, with brief annotations.

The main contributor in the early history of Nebraska lepidopterology was R. A. Leussler. He collected throughout the state during and after the initial University expeditions. His earliest paper (1913) treated the butterflies of the Omaha area in Douglas County. His more extensive annotated list of Nebraska butterflies appeared in 1938 and 1939 and is still most helpful to collectors. Leussler included nearly all known Nebraska species, listing 159, but many of these taxa are now considered subspecies. Consequently, there is difficulty in using his work since the nomenclature for many of the species has been changed. Furthermore, his papers were brief and lacked the full account of geographical and temporal distribution of species.

Throughout the early 1900's another little known collector, E. A. Froemel, of Columbus, Nebraska, collected avidly in Platte County. His collection remains in Columbus. None of his work has been published, but his records are incorporated into the present study. In recent times, there have been two other important Nebraska lepidopterists: O. D. Spencer and Steven J. Kohler, both of Lincoln. Their records from their personal collections are also included herein.

Most of the collecting on which this study is based was done during the past ten years (Fig. 2). I began collecting in the Pine Ridge area in 1960 and have since worked in nearly every Nebraska county. In 1967, Dr. Elray S. Nixon (a botanist) and I published a detailed paper (Johnson and Nixon, 1967) on the Rhopalocera of the Pine Ridge.

The culmination of my own research accounts for about two-thirds of the data in this study. The other portion was based on published literature and the unpublished records of many collectors.

METHODS AND PROCEDURES

Standard methods of butterfly collecting, as treated in any popular account of lepidopterology, were used. Only adults were taken, and traps were not used. Rotten fruit was used as bait for females of the genus *Asterocampa* for acquisition of ova on several occasions. Sight records were included only on rare instances, when they constituted the only recent record for a species, and are noted as such. My personal collection of Nebraska butterflies will be deposited in the collection of the University of Northern Iowa. A compiled record of all data on Nebraska butterflies will be left at that institution.

Distribution maps were kept for all species, as were data on the specific locality, date, and collector. During several summers, calendars of adult flight periods were kept for each species to determine voltinism and temporal distribution.

Extensive collections were made throughout the state after 1960 by the Nebraska lepidopterists. Fig. 2 shows the relative amount of this recent sampling in various Nebraska counties. Counties with no sampling since 1960 are left blank. Areas of extensive sampling in the west represent my work and those in the east the work of Mr. Froemel (Platte County), Mr. Spencer and Mr. Kohler (Lancaster County), and the staff of Kearney State College (Buffalo County). I have been able to do frequent sampling in several other western counties; these are indicated with the medium dot.

The collection at the University of Nebraska State Museum was canvassed for records, and historical records were obtained from the Leussler Collection at Ohio State University, Columbus, Ohio.

Collaborators were solicited and their records, primarily based on their determinations, were inserted into the data. In most instances specific identification is sufficiently easy that this method is deemed reliable. In cases where taxonomic assignment is known to present difficulty, I either examined the specimens personally or referred them to specialists.

Available literature was examined and data recorded, and the taxonomic status was updated where appropriate.

The data are presented in an annotated list, which includes geographic and temporal distribution as well as pertinent discussion, and also by distribution maps. The latter are included for forty-eight species. The order of nomenclature follows dos Passos (1964).

ACKNOWLEDGMENTS

A project of this scope cannot be completed without the help of collaborators. I am indebted to Mr. F. Martin Brown, of Colorado Springs, Colorado, for his encouragement and helpful comments throughout the study. In more recent years I have benefited greatly from the help and advice of Dr. John C. Downey, under whose supervision the final manuscript was written as part of my Master's degree work at the University of Northern Iowa. The advice of the other members of my graduate committee, Dr. Virgil Dowell, Dr. Lawrence Eilers, and Dr. Daniel Cahill was also helpful.

I am also extremely grateful for the continued help of Nebraska lepidopterists, Mr. O. D. Spencer, Mr. E. A. Froemel, and Mr. Steven J. Kohler. Mr. Leonard Running spent over six weeks of the summer of 1969 with me in the field and contributed many specimens. Mr. Michael Christenson, a fellow graduate student at the University of Northern Iowa, aided in laboratory work. William Witt did the photography for the publication.

Several others contributed records for this study. These individuals were: Beth Bennett, John Blinde, Nelson Foster, Richard Hardesty, Stanley Longfellow, Elray S. Nixon, Carol Orr, Clifford Quick, Robert Taylor, Mrs. Robert Woodley, and Katherin Zochol.

I am grateful also to the museum curators at the following colleges and universities for records from their collections: The University of Nebraska, The Ohio State University, Southern Illinois University, Chadron State College, Kearney State College, and The University of Northern Iowa.

Thanks are also due to numerous specialists throughout the country who have aided with determinations. When appropriate, these taxonomists are credited in the annotated list.

ANNOTATED LIST

SATYRIDAE

Subfamily Satyrinae

***Oeneis uhleri uhleri* (Reakirt) — The Uhler's Arctic**

The genus *Oeneis* is a montane taxon occurring in both the eastern and western mountain areas of the United States. *O. uhleri* is recorded from Sioux County in the extreme western part of the Pine Ridge, where it occurs on the canyon grasslands. It may also enter Dawes County. There is one annual brood, flying from mid- to late May. The species is sometimes very common. The population in the Pine Ridge is close to typical *uhleri*, but specimens are larger and more tawny colored. Markings are concise, particularly the mesial band, and most specimens compare closely with the figure in Holland (1949).

***Cercyonis oetus oetus* (Boisduval) — The Dark Wood Nymph**

The Dark Wood Nymph, a species found throughout the sage-covered plains of the western United States, enters Nebraska in the Pine Ridge. Cary (1901) reported it as common in the sagebrush areas of the Ridge in July. The only recent record is a specimen which I took near Crawford, Dawes County, on 6 July 1962, in a grassy area north of the escarpments.

***Cercyonis meadii* (Edwards) — The Mead's Wood Nymph**

C. meadii is a montane satyr occurring in the woodlands of the Rocky Mountain states. There are only a few records in Nebraska. Old specimens from Monroe Canyon, Sioux County, are in the University of Nebraska Collection. They lack full data but the labels indicate that they were probably taken in August, 1921. The only recent series were from the same locale and collected by Nelson Foster. These specimens, which I had originally verified, have since disappeared. Cary (1901) mentions a sight record in Monroe Canyon. The species should be sought in the grassy areas amid the pine stands in northwestern Nebraska.

***Cercyonis pegala* (Fabricius) — The Wood Nymph**

This common species is a highly variable entity and infraspecific segregates are still disputed throughout North America. Several races are presently accepted by taxonomists, even though forms resembling these races occur within so-called "stable populations". Hence the reported occurrence of four "subspecies" in Nebraska.

When series of specimens from throughout the state are examined most are best associated with the name *C. p. olympus* Edwards. In the eastern part of the state *p. olympus* shows slight tinges of the orange-yellow forewing patch, which is supposedly typical of the taxon *p. alope* in eastern and southern areas of the United States. Hence, the latter name has been used by some collectors for Nebraska material.

Another subspecies occurs in the state with quite typical individuals. Steven J. Kohler, of Lincoln, Nebraska, has three specimens in his collection from Holdrege, Phelps County, 25 July 1968 which are *p. texana* Edwards. The yellowish-orange patch is extensive and the underside is light with large eyespots on the hindwing. These specimens were taken flying with *p. olympus*. No doubt, more of these individuals occur in southern Nebraska.

A fourth "subspecies," *p. nephela*, has been reported in the early literature (Barber, 1894; Cary, 1901). These specimens are no doubt *p. olympus* and the use of the name *nephela* is probably a result of these eastern collectors' familiarity with the subspecies in the northern Mississippi Valley, and a lack of experience with more western *p. olympus*. The latter was named only a few years before these writers' publications appeared.

There is one annual brood of this species in Nebraska. It flies throughout July and, with fewer numbers, into August and early September. Females emerge about a week or two weeks after the males.

***Neominois ridingsii ridingsii* (Edwards) — The Ridings' Satyr**

N. r. ridingsii is a western species characteristic of dry grasslands in the Rocky Mountain states. It has been taken in two areas of western Nebraska exhibiting grassy plains at near 5000 ft. altitude. These are Sioux County in the Pine Ridge, and Kimball County in the southwest "panhandle." All of the records are old and are dated from mid-May to late June, indicating one annual brood. The largest series of specimens, from Harrison, Sioux County, is in the University of Nebraska Collection. The Kimball County specimens were taken 24 June 1933 and are in the Leussler Collection at the Ohio State University, Columbus, Ohio. The species should be sought in the canyon meadows of the western escarpments, but disappearance of undisturbed prairie has no doubt limited its distribution in the state.

***Coenonympha ochracea ochracea* Edwards — The Ochre Ringlet**

The genus *Coenonympha* is a northern and montane taxon occurring throughout the Holarctic Region. The species *C. o. ochracea*, has been recorded in recent years only from Dawes and Sioux County in the Pine Ridge. Leussler (1938) recorded it also from Cherry County, the area of the Niobrara River escarpments, but I have not found it there. It seems possible that the species occurs in the Wildcat Range, but it is as yet unrecorded from there. Suitable bioxes exist in all of the above areas. There is an old record, very doubtful, from Lincoln, in Lancaster County, in the University of Nebraska Collection. It is undated. In the Pine Ridge, the Ochre Ringlet has one annual brood which flies from early to late June. Specimens from the Pine Ridge compare favorably with *o. ochracea* as discussed in Johnson and Nixon (1967). Merritt Cary (1901) also used this name. Leussler chose to refer his Cherry County specimens to the species *inornata*. I have not seen these specimens.

***Euptychia cymela* (Cramer) — The Little Wood Satyr**

The Little Wood Satyr is a common butterfly but has not been recorded west of Nebraska. The species has been taken in twenty-six Nebraska counties as illustrated in Fig. 3. Brown *et al.* (1957) does not mention the species from Colorado, but I have found it common in Keith County, Nebraska, near Kingsley Dam, close to the Colorado border. There is no major topographic or vegetative region of the state where it is not recorded. There are two broods—the first from late May through June and the second from mid- to late July. I discussed the distinction of Nebraska specimens from their eastern counterparts in my 1967 paper. Nebraska specimens generally exhibit the darker underside, a trait most notable in the western Nebraska specimens.

Subfamily Lethinae:***Lethe eurydice* (Johannson) spp. — The Eyed Brown**

In 1916 (dos Passos, 1964) Leussler described the subspecies *fumosus* from specimens taken in Douglas County in eastern Nebraska. Since then this entity has been considered extinct. Steven J. Kohler, of Lincoln, Nebraska, has been searching for populations near the type locality in recent years in hope of “rediscovering” individuals which fit the original description.

Recent records of *L. eurydice* from Nebraska are from six counties in the northwest as illustrated in Fig. 4. There is a single annual brood, flying throughout July. The trinomial designation of these specimens is yet unknown, since there is no named subspecies west of Leussler's *fumosus*. Both Mr. Kohler and I feel that it is too early, and that there too few specimens to make a decision on their subspecific status. West Nebraska specimens are not typical *fumosus*, however, fresh specimens being somewhat smaller and darker than fresh eastern material. If Mr. Kohler can rediscover the typical *fumosus* in the eastern part of the state, it will be interesting to compare these with the scattering of specimens from the west.

***Lethe portlandia* (Fabricius) — The Pearly Eye**

Although the Pearly Eye is known in Nebraska from only six eastern counties (Fig. 5), its known distribution extends from the Kansas border north to Columbus, and from the Missouri River west to Hastings. Mr. Froemel has taken it frequently at Columbus. Nebraska collecting dates range from a spring brood in early June to mid-July, to an apparent late summer brood in early August. These areas were originally tall-grass prairie but now are under extensive cultivation.

DANAIDAE

Subfamily Danainae

Danaus (Tasitia) gilippus (Cramer) — The Queen

D. gilippus is a southern representative of the genus *Danaus*. Most records for the Queen in Nebraska are from the eastern part of the state, where it may be a summer resident (Fig. 6). None of the records for the species is recent. E. A. Froemel reports two females, one from 1934 and the other from 14 July 1937. The only other records are in the University of Nebraska Collection: Mitchell, Scotts Bluff County—female, 20 August 1916; McCook, Red Willow County—female, 20 July 1913; Lincoln, Lancaster County—male, 17 July 1921. There is also a specimen, reputedly from Hastings, Adams County, in the Hastings Museum.

Danaus (Danaus) plexippus plexippus (Linnaeus) — The Monarch

D. plexippus is a common species ranging throughout many parts of the world. It flies throughout the state of Nebraska, being reported from nearly forty of the ninety-three counties. Each year are several overlapping broods from May to October. To my knowledge there have been no recorded massive migrations of the species in Nebraska. The foodplant is milkweed (*Asclepias* sp.).

NYMPHALIDAE

Subfamily Heliconiinae

Agraulis vanillae (Linnaeus) — The Gulf Fritillary

This southern species has been captured a few times in eastern Nebraska. It is not a resident but strays north from its usual southeastern distribution. In the east, Klots (1951) mentions it as far north as New Jersey. E. A. Froemel has three males from 11 June 1939, taken in Columbus, Platte County. O. D. Spencer has a specimen from Lincoln, Lancaster County, 25 October 1963, and there are other Lincoln specimens in the University of Nebraska Collection from the 1920's. I have a sight record from Table Rock, Pawnee County, 18 June 1969.

Dryas julia (Fabricius) — Julia

Leussler (1938) reported a specimen taken by Mrs. W. B. Graham at Omaha, Douglas County, September 1908. Since neither the foodplant, Passion Flower (*Passiflora*), nor favorable climate for the species occur in Nebraska, he postulated that this insect was introduced as an egg or larvae on some tropical plant. The species is a resident in the United States only in Florida and the Gulf States.

Heliconius charitonius Linnaeus — The Zebra

The Zebra, another casual visitor to some northern states, is recorded only once in Nebraska, by E. A. Froemel in Columbus, Platte County, in 1939. The species is a resident of Florida and the extreme southeastern United States and has strayed into Kansas and Colorado (Field, 1938; Brown *et al.*, 1957).

Subfamily Argynninae

Euptoieta claudia (Cramer) — The Variegated Fritillary

E. claudia is a tropical species which has established itself on several Nearctic plants like violets and pansies (*Viola* sp.). It occurs throughout Nebraska annually in several overlapping broods from late May to September.

Speyeria (*Speyeria*) *aphrodite* (Fabricius) complex — The Aphrodite Fritillary

Several subspecies of *S. aphrodite* have been recorded from various parts of the state. The species distribution in Nebraska is shown in Fig. 7. It has one extended brood which flies from June into September. In the west (Pine Ridge and Wildcat Range) *S. aphrodite* specimens are best referred to the western subspecies *ethne* Hemming. They vary little from individuals of that taxon in eastern Wyoming. In eastern Nebraska there are few recent records but old specimens have been consistently called subspecies *a. alcestitis*. This is probably correct. Brown *et al.* (1957) mentions *alcestitis*-like individuals as far west as east-central Colorado.

Speyeria (*S.*) *cybele cybele* (Fabricius) — The Great Spangled Fritillary

Though *S. cybele* has been taken in only twenty counties (Fig. 8), it no doubt ranges across the entire state. It is more common in the east than in the west. The species flies as early as the first week of June and extends into mid-August. In the west it is most common in mid- and late July. Although fresh individuals occur throughout the period, the species exhibits the extended single brooding of all the speyerids. All specimens which I have seen from Nebraska represent the typical subspecies *c. cybele* Fabricius. There are, however, individuals in the west that are less fulvous on the upperside, with a deep chocolate brown disc on the underside of the hindwings. These approach some aspects of ssp. *charlottii* Barnes, though there is no reduction of the silver spots.

Speyeria (*S.*) *atlantis* (Edwards) — The Atlantis Fritillary

S. atlantis is a western montane species with its most common occurrence near Nebraska in the Black Hills of South Dakota. There are no recent specimens of the taxon from Nebraska, but old records and series do exist, all from mid-July, 1901, in Sioux County. Records are included in all of the old papers up through Leussler (1939), and have been called subspecies *laurana* dos Passos and Grey, *electa* Edwards, and *hesperis* Edwards. Grey, Moeck, and Evans (1963) pointed out the confusion in the taxonomy of the species in western South Dakota. Even if recent specimens from Nebraska were available, a specialist's opinion would be necessary.

Speyeria (*S.*) *callippe meadii* (Edwards) — The Callippe Fritillary

This montane insect was recorded from the Pine Ridge by the early University of Nebraska expeditions (Barber, 1894; Cary, 1901),

and some of the specimens are still in the University Collection. These were taken from late June to mid-July. No recent specimens were known until I captured it in the Wright Gap, south of Melbeta, in the Wildcat Range, 28 June 1969. I have no doubt that it occurs in both the Pine Ridge and Wildcat Range.

***Speyeria (S.) zerene* (Boisduval) — The Zerene Fritillary**

There are two specimens from my large series of the *coronis-zerene* complex which are *S. zerene*. L. Paul Grey, of Lincoln, Maine, has seen one of these specimens and is of the same opinion, the second specimen is similar. I discussed the maculation of west Nebraska *zerene* and *coronis* in my 1967 paper (loc. cit.). The two zerene specimens, one from Sowbelly Canyon, Sioux County, 25 July 1964, and the other from the Wright Gap, Wildcat Range, 28 June 1969, are smaller than the usual *coronis*. They are lighter on the upperside and, most diagnostically, exhibit a disc on the underside of the hindwing which is nearly devoid of any brown and much the color of the light submarginal band. These specimens approach ssp. *garetti* Gunder. There are old series of *zerene* collected from mid-July from the same areas in the Pine Ridge in the University of Nebraska collection.

***Speyeria (S.) coronis* (Behr) — The Coronis Fritillary**

S. coronis is a common fritillary in the Pine Ridge and Wildcat Range from late June through July. Among its numbers fly a few *zerene* Boisduval. The maculation is close to that of ssp. *halcyone* Edwards which occurs in eastern Wyoming, but with less brown and more grey-green on the basal disc and similarly along the edging of the marginal silver spots.

***Speyeria (S.) edwardsii* (Reakirt) — The Edwards' Fritillary**

This western fritillary is restricted in Nebraska distribution to the escarpments of the western counties (Fig. 9). The single brood usually appears about the last week of June, and fresh specimens are on the wing throughout July and occasionally into early September. Sometimes the butterfly is found well out onto the plains; one specimen is reported from 25 June 1962 from Alliance, Box Butte County, at least forty miles south of the Pine Ridge.

***Speyeria (S.) idalia* (Drury) — The Regal Fritillary**

S. idalia is an eastern fritillary which apparently ranges over the entire state of Nebraska (Fig. 10), being recorded from eleven widespread counties. It is more common in the east but there are several records from the Pine Ridge. Though there is only one brood, it ranges from early June to mid-September.

***Boloria (Clossiana) selene* (Schifferrmuller) — The Silver-Bordered Fritillary**

Mr. Steven J. Kohler is working to clarify the infraspecific taxonomy of Nebraska *selene* through extensive collecting and rearing.

In 1928 (dos Passos, 1964), Holland named the subspecies *nebraskensis* from Dodge County specimens. Just how this taxon relates to other Nebraska material is in doubt. There are other recent records of *nebraskensis* in the eastern counties (Platte, Saunders, and Cass). However, the species has also been found in two western counties (Sheridan and Cherry) (Fig. 11). Mr. Kohler captured fifty-two specimens at Smith Lake, Sheridan County, 1 August 1968, and I have two sight records from Valentine, Cherry County, 24 May 1969. Mr. Kohler's specimens do not appear to be typical *nebraskensis*, being quite small, nor are they *myrina* Cramer, a subspecies of general eastern distribution in the United States. It is still uncertain whether the species has a more widespread Nebraska distribution. E. A. Froemel has taken *selene* in Platte County, just west of Dodge County, and prefers to use the subspecies *myrina*. This would indicate that as the insect ranges west it varied from Holland's taxon. Hopefully, Mr. Kohler will find through rearing whether Nebraska specimens represent more than one valid taxon or how environmental condition may alter some wing characters.

Subfamily Melitaeinae

Euphydryas anicia bernadetta Leussler — The Leussler's Checkerspot

E. anicia is a common butterfly throughout the northern Rocky Mountains. Leussler (1920) named this subspecies from specimens captured in Sioux County. Though it is unrecorded elsewhere, it is common in spring in that county flying in a single brood from mid-May to early June in the canyon grasslands.

Melitaea (Microtia) pola Boisduval — The Pola Checkerspot

This is a common species in the western United States. There are five specimens of *M. pola* from Sioux and Dawes County in the University of Nebraska Collection. They were collected in late June and early July. Only one is labeled as to year: 1921. No recent specimens are known, nor do I know of other Nebraska specimens of this entity. The foodplant is yet unknown but there is little reason why such a common montane butterfly should not occur in the Pine Ridge.

Melitaea (M.) ismeria carlota (Reakirt) — The Huebner's Crescent-spot

This species apparently ranges over the entire state of Nebraska. It has been captured in twenty-eight widespread counties. It flies annually from mid-May to September, indicating several broods. The foodplant is *Helianthus* sp., which is common in distribution throughout the state.

Melitaea (M.) nycteis drusius (Edwards) — The Silvery Crescent-spot

Due to the general and widespread distribution of this species in the eastern United States, I have no doubt that it ranges over most of Nebraska. However, it has been recorded from only twelve

counties, and none of these is in the southwest (Fig. 12). It could be overlooked as *M. i. carlota* in the field. In the areas where it has been taken it is abundant. There seem to be two broods, ranging from early June to early July and then another appearance in mid-August. The latter brood is the smallest in number, only a few records being known.

***Phyciodes (Phyciodes) vesta* (Edwards) — The Vesta Crescent-spot**

This is a plains species known to be a resident of Colorado (Brown, *et al.*, 1957) and Kansas (Klots, 1951). Leussler (1938) reported a single specimen from Omaha, Douglas County, 14 July 1912. The species is a rarity in the northern United States.

***Phyciodes (P.) picta* Edwards — The Painted Crescent-spot**

A species characteristic of the southwestern United States, *P. picta* is known in Nebraska from two specimens. L. M. Gates took one female at Mitchell, Scotts Bluff County, 30 June 1913. It is in the University of Nebraska Collection. Leussler (1938) reported a specimen from Wauneta, Chase County, 21 June 1933.

***Phyciodes (P.) campestris camillus* Edwards—The Camillus Crescent-spot**

Due to its general western distribution in the United States, I had expected the occurrence of this species in the Pine Ridge, but no specimens were known until Richard Hardesty captured it in Smiley Canyon, Sioux County, 8 June 1967. These remain the only known Nebraska records of *camillus*.

***Phyciodes (P.) mylitta* (Edwards) — The Mylitta Crescent-spot**

P. mylitta is a western *Phyciodes*. I described the maculation of specimens of this species from the Pine Ridge in my 1967 paper (loc. cit.). They are not subspecies *mata* Reakirt (= *barnesi* Skinner) and much more typical of the nominate *mylitta*, especially on the underside. The upperside of Pine Ridge material has an almost striped appearance. There are only a few specimens, taken the second week in June, 1961, near Chadron, Dawes County.

***Phyciodes (P.) phaon* (Edwards) — The Phaon Crescent-spot**

P. phaon is a species characteristic of the southeastern United States. Mr. Froemel has taken it in Columbus, Platte County, on 11 May 1938—female, and on 8 June 1939—male. I have another from Monroe Canyon, Sioux County, 14 July 1965. This specimen from the Pine Ridge represents a northerly extreme for the species in the United States. *P. phaon* has been taken once in Colorado (Brown *et al.*, 1957).

***Phyciodes (P.) batesii* (Reakirt) — The Bates' Crescent-spot**

P. batesii is a species which occurs commonly in the northeastern United States and Canada. I have captured it often in the Pine Ridge, the only locality known for it in the state, seemingly a western

extreme for its North American occurrence. About a dozen specimens have been collected by Dr. Nixon and me, and range in time from late June to mid-July in the Ridge canyons. The insect is single-brooded in the northeastern United States (Klots, 1951). Its foodplant is asters (*Aster* sp.).

***Phyciodes (P.) tharos* (Drury) — The Pearly Crescent-spot**

P. tharos is a common butterfly throughout the state, reported from twenty-five widespread counties. There are at least two broods, one from May to mid-June and a second from late June or early July flying into late August. The foodplant is *Aster* sp.

***Phyciodes (Tritanasea) texanna* (Edwards)—The Texas Crescent-spot**

P. texanna is a species characteristic of the gulf states, straying north into Kansas (Field, 1938) and Nebraska. Mr. Froemel, in Columbus, Platte County, has collected it as recently as 1952. His two records are from Columbus, 20 July 1935—male; and 19 October 1952—female. The latter is apparently from a fall brood. There is also an old record from Stapleton, Logan County, 24 June 1938. Leussler (1938) reports several specimens from Omaha, Douglas County, all from the fall.

***Chlosyne lacinia adjutrix* Scudder — Scudder's Patched Butterfly**

This is a casual species in Nebraska native of Mexico and southern Texas. Steven J. Kohler has taken two specimens in eastern Nebraska counties. They are from Lincoln, Lancaster County, 8 August 1968—male, and Ashland, Saunders County, 11 August 1968—female. These are the only recent records. Leussler (1938) reports one specimen from Omaha, Douglas County, 15 October 1920.

Subfamily Nymphalinae

***Polygonia progne* (Cramer) — The Gray Comma**

P. progne is an eastern species finding its western limits in Nebraska and Kansas. Although records of *P. progne* are found throughout the old literature on Nebraska Rhopalocera, its present distribution is still confusing. There are old specimens in the University of Nebraska Collection from Monroe and Warbonnet Canyons, Sioux County, from early June to early September. I have not found it in this area in recent years. However, I have a number of specimens which were taken along with *P. comma* in Beatrice City Park, Gage County, 18 June 1969, which prove its occurrence in eastern Nebraska.

***Polygonia zephyrus* (Edwards) — The Zephyrus Angle-wing**

P. zephyrus, a species characteristic of the western United States, is not uncommon at certain times in the Pine Ridge. It has been taken there by me in Dawes and Sioux Counties. Steven J. Kohler also has a specimen from Valentine, Cherry County, 16 July 1968. In the Pine Ridge, it is taken most commonly throughout July, but I have a spring record from 30 May 1964, indicating there may be two broods.

***Polygonia hylas* (Edwards) — The Colorado Angle-wing**

P. hylas, a montane species native of the Rocky Mountains and Great Basin, was not recorded from Nebraska in the old papers. I have two specimens from Sioux County, both from Monroe Canyon. One was taken by me on 9 July 1964, and the other by Dr. Nixon on 6 July 1965.

***Polygonia satyrus* (Edwards) — The Satyr Angle-wing**

Differentiation of western Great Plains *P. satyrus* and *Polygonia comma* by the maculation of wing undersides can be very misleading. The most reliable wing character for *P. satyrus* is the brightness of the upperside, especially the concise brightness of the hindwings. Specimens reported by Leussler (1938) from the Pine Ridge canyons are in the State Museum at Lincoln. Although I had originally thought differently, I am now of the opinion that the entire stock of recent specimens which have been called *P. satyrus* (Johnson and Nixon, 1967) are best referred to *P. comma*. Thus, rediscovery of *P. satyrus* in the Pine Ridge will prove that the two are sympatric there. Leussler's specimens indicate the typical single brood, all being from mid- to late June. The state range, determined by the old records, is presented in Fig. 13.

***Polygonia comma* (Harris) — The Comma**

Consistent with the treatment of *P. satyrus*, I prefer to present *P. comma* as having the statewide range indicated in Fig. 14. This, however, does not explain why the species is not reported from Colorado (Brown *et al.*, 1957) or Wyoming (Clifford D. Ferris, Univ. of Wyoming, study in progress). I have referred the problem to Mr. John Belicek (University of Alberta, Edmonton) who is beginning a zoogeographical study of the genus. *P. comma* in Nebraska occurs as early as April, with summer form "*dryas*" reported by July. A fall brood extends from mid-August to mid-October.

***Polygonia interrigrationis* (Fabricius) — The Question Mark**

The Question Mark is a familiar butterfly throughout the eastern United States. Although it is not recorded extensively in Nebraska I have no doubt that it occurs throughout the state. Its twenty county records are well distributed over the various areas of Nebraska (Fig. 15). Its temporal distribution is diverse, ranging from early June to mid-October. There may be up to three broods. The species is most easily collected on garden flowers in towns.

***Nymphalis antiopa* (Linnaeus) — The Mourning Cloak**

Due to its wide distribution in the United States, *N. antiopa* no doubt occurs throughout the state, though its sporadic periods of flight have left it rather uncommonly recorded. However, its twenty county records occur in all parts of the state. Individuals which hibernated are in the air in late March and the species can still be

taken in October. There seems to be two extensive broods, with the second beginning in mid-July.

***Nymphalis milberti* (Godart) — The Milbert's Tortoise Shell**

A species typical of woodlands in the north and western United States, *N. milberti* is essentially limited in Nebraska to the woodlands of the west, where it has been taken in Dawes, Sioux, Sheridan, and Scotts Bluff Counties. However, it has been recorded once from the eastern part of the state (Columbus, Platte County) in the spring of 1934 (Fig. 16). It is very local, sometimes abundant, other times scarce. In the northwest it appears to be tri-brooded, occurring from mid-May to mid-August.

***Nymphalis vau-album j-album* (Boisduval and LeConte) —
The Compton's Tortoise Shell**

The Compton's Tortoise Shell is known in Nebraska only from Monroe Canyon in Sioux County, where it has been taken both recently and in the past. I have two specimens from there taken on 19 July 1963 and 25 July 1964. On the latter date there were others flying but only one was collected. The old record is in the University of Nebraska Collection and taken on 1 September 1921.

Subfamily Vanessinae

***Junonia coenia coenia* (Huebner) — The Buckeye**

Records for the Buckeye are from widely scattered localities in Nebraska (Fig. 17). Old specimens exist from the west in Dawes and Cherry Counties; one of these is undated and the other from Barber (1894). There are more recent records from the east, the most probable area for the occurrence of the species, considering its general distribution in the United States. Mr. Froemel has taken it in Columbus, Platte County, a number of times in July, August, and September, indicating the typical two broods. There are records for five other eastern counties, but only one since Leussler's time: Mr. Kohler's specimens from Dead Timber Recreation Area, Dodge County, 12 August 1968. There is also an undated specimen from Buffalo County, in the Kearney State College Collection.

***Vanessa caryae* Huebner — The Western Painted Lady**

V. caryae is a Painted Lady characteristic of the western United States. Brown *et al.* (1957) mentioned its easternmost occurrence as being Colorado. It is not a resident of Nebraska but has made at least one invasion into Nebraska's western counties. In 1961, September and October, it was taken quite commonly by Nelson Foster and me throughout the Pine Ridge. It has not been collected since, in any area of the state, and is unreported in any of the old literature.

***Vanessa cardui* (Linnaeus) — The Common Painted Lady**

V. cardui is the common Painted Lady of eastern North America. Reported from nearly thirty counties, it is a sporadically common insect in Nebraska. In years when it is common it can be found in

almost any habitat, but in other years it can be a rarity. Adults are on the wing anytime from May to October. It has up to three broods, with extensive overlapping. There is one reported migration of the species in Nebraska, in Scotts Bluff County, 1965 (Howe, 1967).

***Vanessa virginiensis* (Drury) — The Hunter's Painted Lady**

V. virginiensis, another Painted Lady occurring throughout the United States, is reported commonly in both eastern and western Nebraska, but lacks records in the central areas of the state (Fig. 18). This is probably due to oversight since it is often overlooked as *V. cardui* in the field. I assume that it flies everywhere in the state. There are two broods, the first from May to at least late June and the second in mid-July extending into September.

***Vanessa atalanta* (Linnaeus) — The Red Admiral**

The Red Admiral is one of the most widely captured of Nebraska butterflies, reported from nearly sixty counties. There are two broods, with adults emerging during the same time spans throughout the state. The first brood is from early May to mid-July and the second from mid-August through September. Adults of the last brood are less common than the first.

Subfamily Limenitidinae

***Limenitis weidemeyerii* (Edwards) — The Weidemeyer's Admiral**

A species characteristic of the pine forests of the western United States, *L. weidemeyerii* occurs in all the coniferous forest areas of Nebraska's western counties. The Pine Ridge material is subspecies *oberfoellii* Brown. It flies from the second week in June through July and sometimes into August. There is only one sight record from the Wildcat Range, but the species should be common there. I observed the single known record in Wildcat Hills Park, 29 June 1969. Barber (1894) records the species from the pine areas of Cherry County. This butterfly might eventually be found in all the wooded areas of western part of the state (Fig. 19).

***Limenitis archippus* (Cramer) — The Viceroy**

The Viceroy is a familiar butterfly found east of the Rocky Mountains in North America. It ranges across the state of Nebraska. Within any one area it is not a common butterfly but is found most frequently near Willow (*Salix* sp.), its foodplant. In all it has been taken in fifteen counties (Fig. 20), from late May to September. The second brood begins in mid- or late July.

***Limenitis arthemis astyanax* (Fabricius) — The Red-spotted Purple**

This species has a well-defined distribution in eastern Nebraska (Fig. 21), occurring as far north as Dixon County and ranging over the entire eastern area west to Valley and Buffalo Counties. There are records from early May to late September. There are three overlapping broods. Mr. Froemel reported to me in correspondence two hybrid specimens of *L. astyanax* and *L. archippus* from 4 September 1963 in Columbus, Platte County.

Subfamily Hurytelinae***Mestra amymone* (Menetries) — The Amymone**

This butterfly is not a resident of Nebraska; its foodplant, *Tragia* sp., is a tropical variety. The amymone strays north commonly into Kansas and Colorado (Brown, *et al.*, 1957). In Nebraska it has been taken three times in recent years. Mr. Froemel has a specimen from Columbus, Platte County, 20 October 1950; Dr. Stanley Longfellow at Kearney State College has taken it in Kearney, Buffalo County, 7 October 1968; O. D. Spencer collected one at Dead Timber Recreation Area, Dodge County, 22 August 1968.

Subfamily Apaturinae***Asterocampa clyton* (Boisduval and LeConte) —****The Tawny Emperor**

This species has not often been found but seems to be locally common (Fig. 22). The largest observed series is in the Kearney State College Collection collected in late September, 1967, indicating a fall brood. Mr. Froemel has taken it in Columbus, Platte County, in early September, 1963. There are older June records in the University of Nebraska Collection from eastern counties and Robert Taylor also has two males from Bellevue, Sarpy County, taken on 30 June 1965, indicating an early summer brood. There is a single record from the west, from Sioux County, 30 June 1908 in the University of Nebraska Collection.

Asterocampa celtis* (Boisduval and LeConte) complex —*The Hackberry Butterfly**

There are two "subspecies" of *A. celtis* in Nebraska. *A. c. celtis* Boisduval and LeConte flies over the entire state in areas where hackberry (*Celtis occidentalis* L.) occurs (Fig. 23). The subspecies *A. c. antonia* Edwards occurs only in the deep canyons of the Pine Ridge. Dr. W. J. Reinthal has reared individuals from eggs of the latter population and was able to obtain adults of both subspecies as well as "intraspecific hybrids." Exactly how this relates to the taxonomic status of the species complex can be known only to a specialist like Dr. Reinthal, and results of the first experiments with rearing were generally inconclusive except to prove that typical *antonia* individuals were present in Nebraska. These latter types may also occur in the Wildcat Range since I have taken them in Lone Tree Canyon, Goshen County, Wyoming, just to the west in the same escarpment. On the plains the typical *celtis* flies from early June to late August, in two broods. The Pine Ridge fauna commonly emerges two or three weeks later than eastern butterflies, usually in late June or early July.

Subfamily Charaxinae

Anaea andria Scudder — The Goatweed Butterfly

There are seven county records for the Goatweed Butterfly which span from extreme west to extreme east: Scotts Bluff, Keith, Lincoln, Rock, Adams, Platte, and Lancaster Counties. I think the rarity of its records is due to its low density. It is never a common butterfly. It may be that it can be found in nearly every county, but one may have to collect an area extensively before coming across any specimens. Mr. Froemel, who has collected in Columbus for many years, has a number of records from that locality. There are two broods in Nebraska; a spring brood from April to late June and a late summer brood from late August through October.

LIBYTHEIDAE

Subfamily Libytheinae

Libytheana bachmanni (Kirtland) — The Snout Butterfly

The Snout Butterfly has been collected in four Nebraska counties. The most recent record is from Fontenelle Forest, Douglas County, 17 August 1968, by Mr. Kohler. Mr. Froemel, in Columbus, Platte County, has taken it in September 1934 and 1935, and there are old records in the University of Nebraska Collection from Lincoln, Lancaster County. Dr. R. W. Dawson, of Pullman, Washington, and formerly of the University of Nebraska at the time of the early expeditions to western Nebraska, has told me of a swarm in Scott's Bluff County on 8 August 1916. Its foodplant, hackberry (*Celtis occidentalis* L.) is widespread in the state.

LYCAENIDAE

Subfamily Plebejinae

Celastrina argiolus (Linnaeus) — The Spring Azure

C. argiolus is a familiar species in both eastern and western areas of North America. I am quite sure that it can be found in every county in Nebraska. It has been reported in varied localities in over thirty counties. It feeds on a variety of hostplants, which helps account for its wide distribution. Specimens of the spring brood, April to May, have not been extensively recorded. Typical summer form specimens, *pseudoargiolus*, are common in June and extend to the third week in July.

Glaucopsyche lygdamus oro Scudder — The Silvery Blue

A species common in the north and western montane areas in the United States, thus far this butterfly has been found only in the coniferous forest of the western counties. Most specimens are best referred to the subspecies *oro* Scudder. It feeds on *Lupinus* and other legumes, and its larval stages are often tended by ants. Its single brood is sometimes common in the Pine Ridge from May to early July, and I saw it in the Wildcat Range in mid-May 1969.

***Scolitantides piasus* (Boisduval) — The Arrowhead Blue**

Though the occurrence of this montane species should be expected in the Pine Ridge, there are only a few specimens known from Nebraska. Dr. John C. Downey took the species in Sowbelly and Monroe Canyons, Sioux County, on 26 June 1962, but no other specimens have been found in recent years. Cary (1901) reported capturing the species in both 1900 and 1901 in Sioux County. The foodplant, *Lupinus* sp., grows in abundance in all the Sioux County canyons.

***Everes comyntas* (Godart) — The Eastern Tailed Blue**

In 1913, Bethune-Baker examined the maculation and genitalia of North American *E. comyntas* Godart and *E. amyntula* Bdw. He concluded that the species were not conspecific and pointed out distinct differences in the genitalia of the two entities. Clench (in Ehrlich and Ehrlich, 1961) and many other authors, chose to refer all North American specimens to one highly variable species *E. comyntas*. Later, in 1966 (personal correspondence with Dr. John C. Downey), Clench reported this in error and testified to the distinctness of the two taxa. He also mentioned the difficulty in separating the two species by macular patterns and was more exact in the discussion of genitalic differences.

The nominate *E. comyntas* has been recorded from many areas of Nebraska. Dr. John C. Downey, Mr. Michael Christenson, and I examined the genitalia of selected males from throughout Nebraska, some of which exhibited differences in wing patterns. And, particularly since I recorded in 1967 a population of *amyntula valeriae* (TL, Lead, S. D.) in the Pine Ridge, we also examined "known" and suspected *amyntula* from California, Colorado, Illinois, Iowa, South Dakota, and Wyoming.

This study verifies that *E. comyntas* and *E. amyntula* are taxonomically distinct, with characters such as the uncus and aedeagus being diagnostic. This was also Bethune-Baker's opinion. In *comyntas* the uncus has a prominent caudally directed dorso-mesial projection, almost a tooth, and the lateral margins of the uncus are definitely "shouldered." The uncus of *amyntula* tapers gradually and evenly, and there is no evidence of a caudally produced shoulder or hump in its margin. Specimens from throughout Nebraska are genitalicly *comyntas*, as are the specimens available to us from the Black Hills of South Dakota. Since the type locality of subspecies *valeriae* is Lead, South Dakota, and this entity seems to be improperly placed as *comyntas*, it may indicate that *comyntas* and *amyntula* occur sympatrically in the Black Hills. Perhaps they also fly together in the Pine Ridge of Nebraska. Efforts to separate the two entities by macular patterns seem futile, with even the extent of orange lunules on the hindwing not being reliable as a diagnostic feature.

E. comyntas is tri-brooded in Nebraska, with adults on the wing from May through September. This is also indirect evidence of the correct taxonomic assignment of Nebraska forms. Western *amyntula* appear to be single brooded.

***Plebejus (Icaricia) acmon* (Westwood) — The Acmon Blue**

P. acmon is a western species occurring most commonly in the southwestern areas of the western Great Plains. I captured the only recent Nebraska specimen in Chadron, Dawes County, 18 May 1962. Cary (1901) reported the species as common at times in the Pine Ridge canyons in Sioux County.

***Plebejus (Icaricia) shasta minnehaha* (Scudder) — The Alpine Blue**

Both Leussler (1938) and Cary (1901) report this species from Sioux County. I have not seen any of the specimens, but seriously doubt if the insect still occurs in the Pine Ridge. In Colorado, the species is known only from above treeline.

***Plebejus (Icaricia) icarioides lycea* (Edwards) —
The Boisduval's Blue**

This butterfly, characteristic of the montane and foothill areas of the western United States, is common in Sioux County where the larval food-plant *Lupinus plattensis* Watts, grows in abundance (Downey, and Fuller, 1961). There is a single brood. The species may enter Dawes County, but no specimens are known from this locale as yet.

***Plebejus (P.) saepiolus* (Boisduval) — The Greenish Blue**

P. saepiolus is a species occurring across Canada and extending southward to the mountain areas of the western United States. There is a single Nebraska specimen known. I captured it on the slope of the Pine Ridge just south of Chadron, Dawes County, on 28 May 1962. It is unrecorded in any of the old literature.

***Lycæideia melissa* (Edwards) — The Edwards' Blue**

The Edwards' Blue occurs throughout Nebraska (Fig. 24). The only area where it has not been reported is in the southeast. It seems to be most common in dryer years. The species begins flying in late May with a second brood beginning in late July and flying until September and October. Western specimens are most like subspecies *melissa* Edwards, but in Custer County, Mr. Running and I found numerous specimens which were very dark, nearly charcoal, on the underside ground color. Genitally, darker forms are identical to the lighter populations of *L. melissa* and no serious thought was given to erecting a trinomial designation for them, if indeed they are a distinctive population. The species is known for its high variability throughout its wide North American distribution.

***Hemiargus isola* (Reakirt) — The Reakirt's Blue**

This species may well occur in every county in the state. Its records indicate that it is widespread (Fig. 25). It may be overlooked by many collectors who mistake its weak flight and small size for

Everes. The adult flight period for Nebraska material ranges from early May to mid-August, though June seems to be the month in which most adults are taken.

***Leptotes marina* (Reakirt) — The Marine Blue**

This species is essentially subtropical but has extended its range northward in the Mississippi Valley as well as in the southwestern United States. Brown *et al.* (1957) reports it also in Colorado. O. D. Spencer has taken four specimens at Lincoln, in Lancaster County. They are from 29 August 1953—female, 18 October 1953—male, and 12 October 1963—two males. These are the only Nebraska records.

***Brephidium exilis exilis* (Boisduval) — The Western Pigmy Blue**

Essentially a western species, Leussler (1938) reported several specimens from eastern Nebraska. There are only two recent specimens. I took one specimen in Chadron, Dawes County, 28 August 1964. The other was captured by Mrs. Robert Woodley, of Richland, Washington, in Hastings, Adams County, 12 August 1964.

Subfamily Lycaeninae

***Lycaena phlaeas americana* Harris — The American Copper**

Leussler (1938) listed this eastern species as a rarity in eastern Nebraska. E. A. Froemel, of Columbus, Platte County, has the only specimens of this species from Nebraska since Leussler's time, taken in Columbus, 21 May 1939. The food-plant, *Rumex* sp. is not uncommon in the state.

***Lycaena dorcas dorcas* Kirby — The Purplish Copper**

Of the Nebraska material in my possession, nearly all specimens resemble the nominate *L. dorcas dorcas*. A few, notably some in E. A. Froemel's collection and an individual from Grant, Perkins County, 26 June 1969, come very close to the descriptions of *heloides*. Until further research is done into the taxonomy of *L. dorcas* and *L. heloides*, I follow Brown *et al.* (1957) and refer all Nebraska specimens to the nominate *dorcas*. The Purplish Copper has been recorded from various areas of the state (Fig. 26). There are two broods, one in early May through June, and another in August with stragglers flying into early October.

***Lycaena rubidus* Behr — The Ruddy Copper**

Although *L. rubidus* is generally considered a western montane species, it is known to occur well out onto the plains of Colorado and Wyoming (Brown *et al.*, 1957). The same situation occurs in Nebraska. Recently I have taken specimens in the Pine Ridge and Wildcat Range as well as Sheridan County on the plains. Older records, in the University of Nebraska Collection, range as far east as Thomas and Custer Counties (Fig. 27). The species nearly swarms in the Wildcat Range canyons in eastern Wyoming. All specimens are from late June or early and mid-July, an indication of a single brood.

***Lycaena xanthoides dione* Scudder — The Great Copper**

In the southeast, this species has been recorded from every county west to Hastings and north to Columbus (Fig. 28). In these areas it is a common butterfly. The species is less common in the northwest, its other area of recorded occurrence, due probably to the more limited occurrence of its foodplant, *Rumex* sp. Individuals from both areas are clearly *dione* Scudder, which varies little throughout eastern North America. In Nebraska, *L. x. dione* flies from mid-June to mid-July. There is one brood.

***Lycaena thoe* Guérin — The Bronze Copper**

L. thoe is never common but has been reported in fourteen counties well distributed over the state (Fig. 29). There seem to be two broods, one from early to late June and the other from mid-August into late October. It feeds on *Rumex crispus* L.

Subfamily Cerydinae***Feniseca tarquinius* (Fabricius) — The Harvester**

The Harvester, a species whose larvae are predatory on alder aphids, is an eastern United States entity but is known from several localities in eastern Nebraska. Specimens were captured in 1969 in Gage, Sarpy, and Cass counties by Leonard Running, Steven J. Kohler, and me. The dates of collecting range from 6 May to 26 June, but it should be found throughout the summer. Leussler (1938) reported it in Nebraska also. There are usually two to three broods in the east-central United States (Klots, 1951).

Subfamily Theclinae***Strymon liparops aliparops* Michener and dos Passos —
The Striped Hairstreak**

This species ranges widely over the United States. In Nebraska it has been captured in six counties, all in the western half of the state (Fig. 30). These records are from Sioux, Dawes, Thomas, Cherry, Keith, Dawson, and Chase Counties and range in date from mid-June to mid-July. The Striped Hairstreak is single brooded.

***Strymon falacer* (Godart) — The Banded Hairstreak**

Leussler (1938) reported this eastern Hairstreak from Nebraska in the southeastern counties. There are two recent records: Valentine, Cherry County, 16 July 1968—male, Steven J. Kohler collector; Lincoln, Lancaster County, 6 June 1965—female, Robert Taylor collector.

***Strymon edwardsii* (Grote and Robinson) — The Edwards' Hairstreak**

Leussler (1938) noted a large population at Omaha, Douglas County, in July 1928. A specimen is known from Lincoln, Lancaster County, 24 June 1899. More recently, Steven J. Kohler has taken the

species in Valentine, Cherry County, 16 July 1968. The foodplant is Oak (*Quercus*) which grows commonly in eastern Nebraska and spreads west along the rivers. I have little doubt that this species is more common than indicated.

***Strymon acadica montanensis* Watson and Comstock —**

The Acadian Hairstreak

This is a widespread species occurring in Canada and south in the mountains of the eastern and western United States. It ranges widely, often occurring well out onto the plains. It has been captured in thirteen Nebraska counties: in the Pine Ridge, the Niobrara escarpments, the Platte Valley, and the east-central area (Fig. 31). It may occur in every county in the state. Specimens are recorded from mid-June to late July.

***Strymon titus titus* (Fabricius) — The Coral Hairstreak**

Although Leussler (1938) mentions this species as occurring over the entire state, there are few known specimens since his time. Steven J. Kohler is responsible for all of the recent captures: Crete, Lancaster County, 7 July 1968—six males; Cozad, Dawson County, 10-11 July 1968—five males; Valentine, Cherry County, 16 July 1968—two males.

***Strymon melinus* (Huebner) — The Gray Hairstreak**

The Gray Hairstreak probably occurs in every Nebraska county. It is a common butterfly over the entire area of the United States. Records from Nebraska are from the west, southeast, and south-central areas (Fig. 32). In 1969, Leonard Running and I found it common only in the south-central area where specimens were assignable to the subspecies *humuli* Harris. All eastern material is best applied to this name. In the west, the specimens are more like subspecies *franki* Field, with a lighter ground color on the underside and red-brown edging of the white lines across the disc. These have been captured in Chase County as well as in the Wildcat Range and Pine Ridge. The species can have many broods, specimens ranging in date from early May to late September.

***Strymon cecrops* (Fabricius) — The Red-banded Hairstreak**

Leussler (1938) reported this species from Nebraska, reputedly collected by Albert Cassell in Nebraska City, and H. G. Barber in Nemaha County.

***Incisalia niphon* (Huebner) — The Eastern Pine Elfin**

I. niphon is the Pine Elfin characteristic of the east-coast forests. Barber (1894) reports it from Nemaha County in southeastern Nebraska. There are no recent records, and I have not seen the specimen reported by Barber. The species may now be absent from the state.

***Incisalia eryphon* (Boisduval) — The Western Pine Elfin**

The Western Pine Elfin is a common species throughout the pine forests of the Rocky Mountains. In Nebraska it is found from early

May into July in the Pine Ridge. It can be collected in large numbers near its foodplant, pine (*P. ponderosa* Laws.). I feel sure that the species must also occur in the Wildcat Range, but there is so little spring collecting done in that area that no specimens are known.

***Incisalia henrici* (Grote and Robinson) — The Henry's Elfin**

This is a widely distributed, but local, species in the eastern United States. Leussler (1938) reported it from Omaha, Douglas County. Mr. Kohler has taken it in Barada, Richardson County, in early May, 1969, and in Nebraska City, Otoe County, on 2 May 1969. The species most likely occurs throughout southeastern Nebraska, but lack of early spring collecting there has left limited records for it. Adults should be sought around red-bud trees when they are first blooming.

***Mitoura siva* (Edwards) — The Siva Hairstreak**

A characteristic mountain species of the western United States, *M. siva* has extended its range considerably to the east in Nebraska (Fig. 33). I have taken it as far east as Rock County, in the Western Red Cedar (*Juniperus scopulorum* Sarg.) of the Long Pine State Recreation Area. This area is at least 180 miles from the Wyoming border. The occurrence of the species in the Halsey National Forest across a wide prairie barrier is more difficult to explain. Perhaps it was introduced as ova on cedar seedlings. I have captured it commonly also on the cedar-covered bluffs above Kingsley Dam, in Keith County. The species is commonly found in both the Pine Ridge and Wildcat Range, and from these localities ventures out onto the plains. The adult flight period for this single-brooded species ranges from late May through late June.

PIERIDAE

Subfamily Euchloeinae

***Euchloe olympia rosa* (Edwards) — The Olympian Marble**

The Olympian Marble is a woodland species occurring throughout the midwestern United States. In Nebraska it has been captured in six counties (Fig. 34). In the west I have captured it throughout the pine forest areas as far east as Rock County. In the east, it has been taken in the deciduous forests of Platte and Nemaha Counties. It flies in one brood from early May to early June. The species feeds on Cruciferae.

***Euchloe ausonides coloradensis* (Edwards) — The Colorado Marble**

This is a western montane representative of the Marble group. Cary (1901) and Leussler (1938) report it in the Sioux County canyons. Though it has never been captured there in recent times, there is no apparent reason why it should be missing. It can be found throughout the summer in eastern Colorado. Perhaps the species has been overlooked as *E. olympia* or other Pierids. This would explain the lack of other and recent records.

***Anthocaris genutia* (Fabricius) — The Falcate Oragne-tip**

The Falcate Oragne-tip, an essentially eastern United States species, has been captured in Nebraska by Mr. Froemel in Columbus, Platte County. His single male specimen is from 1 May 1938.

Subfamily Coliadinae***Nathalis iole* Boisduval — The Dainty Sulphur**

N. iole is a small sulphur occurring throughout the United States. It is reported in ten scattered counties in Nebraska, as far west as Dawes County in the Pine Ridge, to Nemaha County in the southeast (Fig. 35). Many of the more recent records are from the south-central and southwest. There are two broods, one from mid-June to mid-July and the other in the fall, beginning in late August and extending into November.

***Eurema nicippe nicippe* (Cramer) — The Sleepy Orange**

E. nicippe is very common in the southern United States and is much less frequently encountered at the northern margins of its distribution. There are few records for this species in Nebraska. There is a specimen from Lincoln, Lancaster County, 23 October 1910, and one from McCook, Red Willow County, 20 June 1913 in the University of Nebraska Collection. Barber (1894) reported a specimen from Saunders County.

***Eurema lisa lisa* Boisduval and LeConte — The Little Sulphur**

This common eastern United States species has been collected a number of times in recent years in southeastern Nebraska; as far north as Cuming County and south to Nemaha County (Fig. 36). The Platte County records are the farthest west. There are two broods, one in mid-June through July and another beginning in early August.

***Eurema mexicana* (Boisduval) — The Mexican Sulphur**

E. mexicana is a resident of many southeastern and western states in the United States. In Nebraska there are records from eight counties. In the east it is probably a resident, but specimens from the west are generally tattered and probably blown in by the wind. In western Nebraska the butterfly has been captured in Dawes, Sioux, and Logan Counties and in the east in Lancaster, Dodge, Sarpy, and Douglas Counties. The records vary in time or year, some from mid-July but the bulk from September and October. The species usually has two to three broods, but there is much overlapping.

***Kricogonia lyside* (Godart) — The Lyside**

K. lyside is a southern species which on occasion invades Nebraska, Kansas, and Colorado. Leussler (1938) reported specimens from Lancaster County in eastern Nebraska. It is likely that the species strays into Nebraska, but no recent specimens are known.

***Phoebus sennae eubule* (Linnaeus) — The Cloudless Sulphur**

A common species in the southeastern United States, the Cloudless Sulphur has a rather well-defined range in southeastern Nebraska.

It has been found as far north and west as Platte County and is reported, especially in the old literature, in five other southeastern counties (Fig. 37). In recent times, records for the species have become fewer. Nearly all the dates of collection range from late July through mid-September. There are usually two broods in the eastern United States (Klots, 1951).

***Phoebus agarithe* (Boisduval) — The Cloudless Orange Sulphur**

E. A. Froemel, of Columbus, writes that he has specimens very much like this taxon in his collection from Columbus, Platte County: a male from 7 July 1940 and a female from 6 July 1941. Brown *et al.* (1957) reports two specimens from Colorado and Leussler (1938) cites a record from Dodge County. The species is essentially southern in distribution.

***Anteos maerula* (Boisduval) — The Yellow Angled Sulphur**

A species native to southern Texas, *A. maerula* is known to stray north on occasion (*e. g.* Colorado, Brown *et al.*, 1957). Leussler (1938) reports a specimen taken by him at Omaha, Douglas County, 20 September 1921. I assume this specimen was a stray and the species is not a regular Nebraska resident.

***Colias (Zerene) caesonina caesonina* (Stoll) —
The Dog's Head Sulphur**

The Dog's Head Sulphur is a species characteristic of the eastern United States, occurring west to Colorado and eastern Wyoming. In Nebraska it flies in the coniferous forests of the west and is also reported frequently from the southeastern counties. There are old records from the Pine Ridge and recent records from the Wildcat Range. In the east there are old records west to Adams County and throughout the lower Missouri Valley (Fig. 38). Mr. Froemel, in Columbus, Platte County, has collected it numerous times. The Nebraska records are mostly from September, though there are June records and the Wildcat Range specimens are from mid-July. There are three broods of the species in eastern North America (Klots, 1951).

***Colias alexandra* Edwards — The Queen Alexandra's Sulphur**

C. alexandra is a species characteristic of the Rocky Mountains. It has entered Nebraska in both the Pine Ridge and Wildcat Range. Although the species is reputedly single brooded, there are specimens from June, July, and August. The majority of the records, and all the recent ones, are from June. I am sure that the butterfly is more common than the records indicate. Its appearance is so close to *C. philodice* on the upperside that most collectors may pass it up, especially since Nebraska is a state where its occurrence would not ordinarily be expected.

***Colias philodice* Godart — The Clouded Sulphur**

C. philodice is a common species throughout the United States.

It has been captured in nearly eighty Nebraska counties. There are three overlapping broods from April through November. It will feed on clover (*Trifolium* sp.), alfalfa (*Medicago* sp.), and lupine (*Lupinus* sp.).

***Colias eurytheme* Boisduval — The Alfalfa Butterfly**

A species characteristic of the entire United States, this butterfly has been collected in some eighty counties throughout the state of Nebraska. It flies from early April until late November, weather permitting. There are several broods.

Subfamily Pierinae

***Pieris rapae* (Linnaeus) — The European Cabbage Butterfly**

The Cabbage Butterfly is a common butterfly in all areas of the United States. In Nebraska it has been captured in some seventy counties. There are several broods with adults on the wing from March to November. Merriitt Cary (1901) reported a specimen of *Pieris napi* L. from the canyons of Sioux County. I do not include it since there is usually a strain of very light *P. rapae* occurring in that area in the spring, and the possibility of misidentification is suggested. Furthermore, the specimen could not be located in the Cary collection at the University of Nebraska.

***Pieris protodice* Boisduval and LeConte — The Checkered White**

P. protodice, a common eastern United States species, has been taken in thirty-two widespread counties in Nebraska. The species can be found nearly everywhere. There are at least three broods; specimens have been captured from late May to late September.

***Pieris sisymbrii* Boisduval — The Colorado White**

This is a montane taxon characteristic of the Rocky Mountains, but occurring east in escarpment areas in both Colorado and Wyoming (F. M. Brown, in correspondence). It flies annually in the Pine Ridge from late April to late May in a single brood. I have seen it locally common on early April days, but usually it is infrequent. Specimens from the Pine Ridge and from eastern Wyoming and Colorado may prove to be a new subspecies (Johnson and Nixon, 1967). More specimens are needed, however, for such an evaluation.

***Appias drusilla* (Cramer) — The Florida White**

A. drusilla is a native of southern Florida and Texas and occasionally strays northward. Leussler (1938) reports taking a specimen at Omaha, Douglas County, 19 August 1909. This species has strayed into Colorado (Brown, *et al.*, 1957) and additional records from Nebraska are quite possible.

***Neophasia menapia* (Felder and Felder) — The White Pine Butterfly**

N. menapia is a Rocky Mountain species occurring commonly east to the Black Hills of South Dakota and Nebraska's Pine Ridge. Dr. Nixon has taken the most recent specimens, from Monroe Canyon in Sioux County, 8 August 1965. Klots (1951) reports the species as far east as Sioux City, Iowa, on the Missouri River, but I am sure that the Pine Ridge forests are its nearly exclusive Nebraska habitat.

PAPILIONIDAE

Subfamily Papilionidae

***Graphium marcellus* (Cramer) — The Zebra Swallowtail**

The Zebra Swallowtail is an eastern taxon occurring from Florida to Wisconsin (Klots, 1951). There are a number of recent records for this species in extreme southeastern Nebraska (Fig. 39). It has been collected in Nemaha County both by early collectors and recently by Dr. Longfellow, at Peru, 7 July 1958. In Richardson County, Nebraska's south-easternmost county, it has been captured several times by Mr. Kohler, in Barada, early May, 1969. The species is several brooded. It feeds on Papaw (*Asimina* sp.).

***Papilio palamedes* Drury — The Palamedes Swallowtail**

A species characteristic of the southeastern United States, Leussler (1913, 1938) reports one specimen taken in Omaha, Douglas County, and one from Dodge County. There are no dates given.

***Papilio troilus troilus* Linnaeus — The Spicebush Swallowtail**

This species gains its name from its most common foodplant, Spicebush, (*Benzoin* sp.). Leussler (1913, 1938) reports one specimen from Omaha in Douglas County, 27 April 1913. The taxon is essentially southeastern in its United States distribution.

***Papilio multicaudatus* Kirby — The Two-tailed Tiger Swallowtail**

A western taxon, this Tiger Swallowtail ranges east in Nebraska much farther than once thought by lepidopterists (Fig. 40). It is the common Tiger Swallowtail in the Pine Ridge and Wildcat Range, but also flies east along the Niobrara escarpments and into Nebraska National Forest in Thomas County. Leussler (1938) mentioned its occurrence in Valentine, along the Niobrara River in Cherry County. This, however, has not been its eastern limit. Barber (1894) reported it from Custer County, and Dr. Longfellow at Kearney State College has taken it at Kearney, Buffalo County, 21 September 1967. This is well past the state's midline. There is also one other record for the species far to the east, Bellevue, Sarpy County, along the Missouri River, 1 May 1910. In the west there are two broods, one in early May into July and again a brood in early August.

***Papilio rutulus* Boisduval — The Western Tiger Swallowtail**

This is the common Tiger Swallowtail in western areas of the United States. It may occur in the Pine Ridge or Wildcat Range. Cary (1901) reports several on 10 July 1901 in Monroe Canyon, Sioux County.

***Papilio glaucus* Linnaeus — The Eastern Tiger Swallowtail**

This species is the common Tiger Swallowtail in eastern Nebraska. It has been captured in nearly every county in the state's eastern third, and ranges as far west as Buffalo and Valley Counties (Fig. 41). There are at least two broods, one in early spring ranging through mid-July, and another in August.

***Papilio cresphontes* Cramer — The Giant Swallowtail**

A common butterfly in the southern United States, Leussler (1938) reported this species in Nebraska as "not uncommon in the east." Mr. Froemel has three specimens from Columbus, Platte County, 19 October 1963, and two others from 23 July 1939 and 30 July 1954. The University of Nebraska Collection has two specimens, both females, from 30 August 1909 and 19 September 1921. These were taken in Lincoln, Lancaster County. Barber (1894) mentions it from several eastern Nebraska counties. The species distribution is shown in Fig. 42.

***Papilio indra* Reakirt — The Short-tailed Black Swallowtail**

A species characteristic of the western United States and montane areas, there are old records for it in both the Pine Ridge and Wildcat Range. The Pine Ridge specimen is a male from Monroe Canyon, 31 May 1900. It was taken by one of the early University expeditions. Leussler took the insect in the Wildcat Range, near Harrisburg, Banner County, 2 June 1919. This specimen is in the Ohio State University Collection.

***Papilio zelicaon* Lucas — The Zelicaon Swallowtail**

Another swallowtail of the western United States, *zelicaon* is found frequently in the spring in the Pine Ridge. It has spread its eastward range surprisingly. There are old specimens from the Wildcat Range and recent captures are from Paxton, Keith County, 5 April 1964. The latter are in the Kearney State College Collection. A spring brood is common in the Pine Ridge, flying from at least early May on through the month. The only summer brood specimen is the Wildcat Range specimen dated August 7 (no year given).

***Papilio nitra* Edwards — The Nitra Swallowtail**

A northwestern United States species, *P. nitra* is extremely rare eastward to Colorado (Brown, *et al.*, 1957) Leussler (1938) reports one specimen from Bull Canyon near Harrisburg, Banner County, 2 June 1919.

***Papilio polyxenes asterius* Cramer — The Black Swallowtail**

I am sure that *p. asterius*, the common Black Swallowtail of the United States, flies in every county in Nebraska. Its fifteen county records are widespread (Fig. 43). It is never common, at least in comparison to the Tiger Swallowtails, but its two broods span the summer. The first is in early May, perhaps the most common, and the second in mid-July.

***Battus philenor* (Linnaeus) — The Pipevine Swallowtail**

B. philenor gains its name from its most common foodplant, Pipevine (*Aristolochia*). There are a number of specimens in the University of Nebraska Collection, all from mid-July 1914. All these specimens are from Lincoln, Lancaster County. There is also a

specimen, reputedly from Hastings, Adams County, in the Hastings Museum. The species is usually localized by the occurrence of its foodplant.

Subfamily Parnassinae

Parnassius phoebis sayii Edwards — The Parnassian

The Parnassians are tail-less members of the Papilionidae and are found in the northern and mountain areas of the Holarctic realm. Several series of *P. p. sayii* are in the University of Nebraska Collection from various canyons in Sioux County. They are all from the early 1900's. There have been no recent captures, but I made a sight record from Monroe Canyon, Sioux County, 2 July 1964.

Note on *Papilio*:

Merritt Cary (1901) reported a specimen of *Papilio bairdii* from Sioux County. This must be misidentification, but the specimen has since disappeared and cannot be checked. *Papilio bairdii* is known to occur east of the continental divide in only a few rare and isolated populations (F. M. Brown, in correspondence). I do not include the species in the state list.

IESPERIIDAE

Subfamily Pyrginae

Epargyreus clarus (Cramer) — The Silver-spotted Skipper

A common United States species, I have little doubt that it flies throughout the state of Nebraska. Its seventeen county records range from border to border (Fig. 44). There are two broods: from mid-May to late June and from early September to early October.

Thorybes pylades (Scudder) — The Northern Cloudy Wing

A species characteristic of woodlands throughout the United States, the Northern Cloudy Wing is a common catch in the coniferous forests of the western part of Nebraska. It is also recorded as far east as Columbus in Platte County. It flies from late May to late June. There seem to be two closely associated broods.

Thorybes bathyllus (Abbot and Smith)—The Southern Cloudy Wing

An eastern member of the genus *Thorybes*, this species has been captured in four east-central counties, all within the first week of June. The counties are Platte, Dodge, Washington, and Saunders.

Staphylus mazana hayhurstii (Edwards) — The Southern Sooty Wing

Klots (1951) mentions this species from Omaha, in Douglas County. The species was once thought to be a true sooty wing and was placed in the genus *Pholisora*. Mr. Froemel, in Columbus, Platte County, has four specimens: 30 June 1965, 30 May 1938, 5 August 1941, and 7 August 1957, all from Columbus.

Erynnis juvenalis (Fabricius) — The Juvenal's Dusky Wing

The genus *Erynnis* includes a number of species of widespread occurrence across the United States. The original foodplant seems to

have been oak (*Quercus* sp.), but the various species have radiated into both general and specific habits as to choice of foodplant (Burns, 1964). Some feed on willow and poplar, and others on forbs. *E. juvenalis* has been mentioned in Nebraska by Klots (1951). He no doubt refers to Leussler's specimens from Omaha in Douglas County reported in his 1913 paper, and to Leussler's mention of its "general" distribution in his annotated list of 1938 and 1939. I have no experience with it in the state.

***Erynnis horatius* (Scudder and Burgess)—The Horatius Dusky Wing**

An eastern United States erynnid, Leussler (1938) reports specimens from Early May and late summer in Saunders, Douglas, and Otoe Counties.

***Erynnis martialis* (Scudder and Burgess) —
The Martial's Dusky Wing**

E. martialis is a prairie erynnid of widespread occurrence in the United States. Dr. Nixon captured two specimens in the Pine Ridge just south of Chadron on 19 June 1965. Leussler (1938) reports other specimens from Douglas and Thomas Counties.

***Erynnis zarruco funeralis* (Scudder and Burgess) —
The Funereal Dusky Wing**

This taxon is of southern distribution in the United States. Two specimens are known from the state, one mentioned in Leussler (1938) from Cedar Bluffs, Saunders County, 30 May 1913 and another from Fremont, Dodge County, 30 May 1921.

***Erynnis lucilius afranius* (Scudder and Burgess) —
The Columbine Dusky Wing**

E. lucilius is a northern erynnid which feeds of columbine (*Aquilegia*). The subspecies *afranius* is typical of the Black Hills of South Dakota. Specimens from Nebraska have been determined by Dr. John M. Burns of the Harvard Museum. It is sometimes common in the Pine Ridge canyons from mid-July to early August.

***Erynnis persius* (Scudder and Burgess) — The Persius Dusky Wing**

Distribution records for this widespread species are scattered. In the Pine Ridge it can be found frequently from early May to mid-June. There are two eastern records: from Platte County, 18 June 1939, and Washington County, 5 June 1969.

***Erynnis brizo* (Boisduval and LeConte) — The Brizo Dusky Wing**

This species feeds on scrub oak (*Quercus ilicifolia*), and has been found in only two Nebraska counties. Leussler (1938) reports a few specimens from Omaha, Douglas County, and Weeping Water, Cass County, taken between April 23 and May 15.

***Pyrgus communis* (Grote) — The Common Checkered Skipper**

P. communis is a common skipper throughout the United States, being reported from thirty-three Nebraska counties. It has many broods, flying from mid-May to September. It can be collected

commonly in almost any habitat and is, at certain times, the most common butterfly of the season.

***Pholisora catullus* (Fabricius) — The Common Sooty-Wing**

This common skipper has been taken in forty counties throughout the state. There are two broods, overlapping, from mid-May to late July. It is commonly taken along roadsides and in open spaces, the species rivals *P. communis* in density.

Subfamily Hesperinae

***Ancyloxypha numitor* (Fabricius) — The Least Skipper**

A common small skipper in the eastern United States, *A. numitor* has been captured in several eastern Nebraska localities. Mr. Froemel has taken it in Platte County and Leonard Running and I have a number of specimens from Gage, Dodge, Thayer, and Jefferson Counties. It is a weak flyer and commonly flies amidst weeds and grasses where it may be overlooked.

***Oarisma garita* (Reakirt) — The Garita Skipperling**

O. garita is essentially a western species, characteristic of the Rocky Mountains. Among the many *O. powesheik* that can be found in the Pine Ridge, a few *garita* occur. The species flies from mid-June to early July.

***Oarisma powesheik* (Parker) — The Powesheik Skipperling**

This is a skipperling common in the midwestern United States. It can be found commonly in the dry canyon meadows of the Pine Ridge from mid-June to early July.

***Hylephila phyleus* (Drury) — The Fiery Skipper**

A southern United States taxon, Mr. Froemel has specimens from Columbus, Platte County, 21 July 1939, and 28 July 1940. Leussler (1939) reports it as rare in the extreme southeastern counties of the state.

***Ycretta rhesus* (Edwards) — The Rhesus Skipper**

Y. rhesus is a plains species characteristic of the southwestern United States. In recent years this species has been taken in the western part of Nebraska. I have specimens from Chadron, Dawes County, 10 June 1961, and 12 May 1962, and also from Bridgeport, Morrill County, 16 May 1965.

***Hesperia attalus* (Edwards) — The Dotted Skipper**

This is a widespread species in the eastern United States, but is known from only one county in Nebraska. Leussler (1939) reports several specimens from the eastern part of the state: one female, Omaha, Douglas County, 21 June 1913, and two females and a male, from the same locality, 17 June 1922.

***Hesperia ottoe* Edwards — The Ottoe Skipper**

H. ottoe is a very rare skipper in Nebraska, as it is throughout the prairies of the central United States. Most of the records in Nebraska are old. Klots (1951) lists it from Omaha, Douglas County,

and Richard Heitzman has told me of specimens taken at Ogallala, Keith County, 27-28 June 1949. The only other records are Leussler's: Monahan Lake, Cherry County, 22 July 1911; Waneta, Chase County, 12 June 1923; Omaha, Douglas County, 27 June 1925; Pilger, Stanton County, 26 August 1925.

***Hesperia pawnee* Dodge — The Pawnee Skipper**

H. pawnee is similar to *H. ottoe*, only the genitalia being truly diagnostic. Leussler's Collection at Ohio State University houses the only representatives of this species from the state. He captured them in Loretto, Boone County, 1 September 1898, and Pilger, Stanton County, 2 September 1922.

***Hesperia pahaska pahaska* Leussler — The Pahaska Skipper**

Leussler (1938) named *H. pahaska* from specimens captured in canyons in Sioux County, Nebraska. The skipper is quite frequently caught in the Pine Ridge and Wildcat Range. It flies from the last week in June to early August. It can be found nearly anywhere in the forested areas, often high on the buttes.

***Hesperia comma colorado* (Scudder) — The Colorado Skipper**

Leussler (1938) reports this species in Nebraska "on the western plains." I have not found it there, but Brown *et al.* (1957) indicates that it ranges into southern Wyoming. It should be sought in Nebraska, especially in the Wildcat Range and other areas adjacent to southeastern Wyoming.

***Hesperia uncus* (Edwards) — The Uncus Skipper**

This species is not common in Nebraska, though it has a number of widely scattered records in the western part of the state (Fig. 45). Richard Heitzman reports specimens from Ogallala, Keith County, 27-28 June 1949. Leussler (1938) reports it in several western counties, and I have taken it in the Pine Ridge, in Dawes County.

***Polites mystic dacotah* (Edwards) — The Dakota Skipper**

P. mystic is a species characteristic of the northeastern United States, ranging southward to Virginia (Klots, 1951). I have two males of the subspecies *dacotah* from the Pine Ridge. These are the only recent Nebraska records, though Leussler (1939) reported it in Sioux County. My specimens are from Kings Canyon, Dawes County, 11 and 29 July 1965.

***Polites manataqua* (Scudder) — The Cross Line Skipper**

This species may prove to be quite generally distributed in Nebraska. It has been taken in four widespread localities. The records are: Kings Canyon, Dawes County, 29 July 1965—two females, Dr. Nixon collector; Stapleton, Logan County, 23 June 1969, K. Johnson collector; and Columbus, Platte County, four records mid-June to early July, Mr. Froemel.

***Polites themistocles* (Latreille) — The Tawny-edged Skipper**

The Tawny-edged Skipper is common throughout Nebraska and the entire eastern United States. It has been captured in thirty

widespread counties, mostly in the eastern and central counties of the state (Fig. 46). There are two broods, not well defined, specimens being known from late May to early August.

***Polites peckius* (Kirby) [= *coras* (Cramer)] — The Peck's Skipper**

This is a common skipper in the eastern United States and in southeastern Nebraska. It is reported from a dozen counties in east-central and southeastern parts of the state. I also have a specimen from the west, taken at Grant, Perkins County. The statewide distribution of *peckius* is shown in Fig. 47. There are many broods, the species flying from late May commonly to late June with some stragglers to late July. The Grant specimen is from 26 June 1969. There is little apparent reason why the skipper should not extend its distribution westward. It feeds on various grasses.

***Wallengrenia otho egeremet* (Scudder) — The Broken Dash**

W. otho is an eastern United States species. Leussler (1939) reports it from Omaha, Douglas County. Mr. Froemel has four males from Columbus, Platte County, taken on 23 July 1939.

***Pompeius verna* (Edwards) — The Little Glassy Wing**

Though *P. verna* is distributed throughout the eastern United States, it has been recorded only a few times in Nebraska. Leussler (1939) reports two specimens from Omaha, Douglas County, 3, 5 July 1912, and another from Plattsmouth, Cass County, 26 June 1930.

***Atalopedes campestris* (Boisduval) — The Sachem Skipper**

A. campestris is a tropical skipper which extends north in the spring and produces a resident fall brood occurring in September and October. In Nebraska it has a wide distribution, east to Platte County, west to the Colorado border and north to the Pine Ridge. There are two broods wherever the species is a year-round resident. Brood one appears in June. In cases where the species is transient, June specimens blown northward produce a second brood in September and October which do not survive the winter. This is the case in Nebraska. In recent years records from the southwestern parts of the state are most frequent (Fig. 48).

***Atrytone delaware delaware* (Edwards) — The Delaware Skipper**

This is a widespread species in the eastern United States, and taken at various points in Nebraska. I have specimens from Western, Saline County, 19 June 1969, south of Western, Jefferson County, 19 June 1969, and to the west, in the Wildcat Range, some specimens from just over the Wyoming border, 13 July 1964. No doubt the species is more widespread than these records indicate.

***Atrytone arogos* (Boisduval and LeConte) — The Arogos Skipper**

A. arogos ranges widely but locally in the eastern United States (Klots, 1951). Leussler (1939) reports this species from several Nebraska localities: Douglas, Cuming, Red Willow, and Custer Counties. In more recent times, I have a specimen from Thayer

County, near Chester, 17 June 1965. Klots (1951) lists a specimen from South Sioux City, in Dakota County.

***Poanes taxiles taxiles* (Edwards) — The Taxiles Skipper**

P. taxiles is a western taxon, occurring from Nevada and western Nebraska southward (Brown *et al.*, 1957). It can be found very commonly in mid-summer in the Pine Ridge canyons. It flies from mid-June to the first week in August. Extreme sexual dimorphism is characteristic of the species.

***Poanes zabulon* (Boisduval and LeConte) — The Zabulon Skipper**

I found a single specimen of this woodland taxon in the Kearney State College Collection, from Kearney, Buffalo County, 18 September 1967.

***Poanes hobomok* Harris — The Hobomok Skipper**

P. hobomok is an eastern United States species seldom occurring to the west. It has been collected in many areas in eastern Nebraska from as far north as Dixon County to Thayer County in the south. There is also a curious record far to the west, from Chadron, Dawes County, taken by me on Spruce, 12 June 1965. This record makes the distribution of the species in the state rather disjointed (Fig. 49). The specimen is in the Richard Heitzman Collection, Independence, Missouri. In Nebraska, *P. hobomok* records have dates ranging from late May to mid-June.

***Euphyes vestris vestris* (Boisduval) — The Dun Skipper**

A common species throughout the United States, the Dun Skipper is common in the coniferous forests of western Nebraska from late June to early August. There are also a few records from eastern counties, all taken by Leonard Running and me in 1969: Beatrice, Gage County, 18-19 June; Lake Alexandria, Jefferson County, 20 June.

***Euphyes bimacula* (Grote and Robinson) —**

The Two Spotted Skipper

Leussler (1939) reported this northern species as very local in eastern Nebraska. He captured it at Omaha and Valley, Douglas County, in early July.

***Euphyes conspiciua* (Edwards) — The Black Dash**

A widespread species in the northeastern United States spreading west to the plains, Leussler (1939) reports this species in late June and mid-July in several eastern localities, all in Douglas County.

***Euphyes dion* (Edwards) — The Dion Skipper**

In the eastern United States, *E. dion* occurs widely but locally. In Nebraska, Leussler (1939) records the species as being "not uncommon locally" from late June to mid-July in Douglas County. I have no recent experience with the species in the state.

***Atrytonopsis hiana* (Scudder) — The Dusted Skipper**

A. hiana is a common spring species throughout the forested areas of western Nebraska, where it flies in the scattered grasslands

among the pine stands. It has been taken in Sioux, Dawes, Scotts Bluff, Banner, and Cherry Counties all within coniferous forest (Fig. 50). It occurs from mid-May to mid-June in a single brood.

***Amblyscirtes vialis* (Edwards) — The Common Roadside Skipper**

This species very likely ranges over the entire state. It is a common species in much of the United States. I took it often in 1969 in five eastern counties: Knox, Cedar, Dixon, Gage, and Platte. It has also been captured in the Pine Ridge. All of my records are from early to mid-June. This skipper is single brooded over most of its northern range (Klots, 1951).

***Amblyscirtes nysa* (Edwards) — The Nysa Roadside Skipper**

This is a southern species occurring commonly in Texas and spreading north into Kansas (Klots, 1951). I have one specimen from Nebraska, taken by me at Rulo, Richardson County, 18 June 1969.

***Amblyscirtes oslari* (Skinner) — The Oslar's Roadside Skipper**

A. oslari occurs in the southwestern United States north along the western edges of the Great Plains. Leussler (1939) reported it as common in the Pine Ridge and along the coniferous escarpments into Cherry County. I have one specimen that I collected in Monroe Canyon, Sioux County, 18 July 1963. I am sure the species must be more common but simply overlooked as *E. vestris*.

***Lerodea eufala* (Edwards) — The Eufala Skipper**

Leussler found this species common at times in eastern Nebraska counties in September and October. It is a familiar skipper of the southeastern United States. Its possible common occurrence in eastern Nebraska is substantiated by Mr. Froemel's several records from Columbus, Platte County, from August to November, 1940-1958. I have never collected in eastern Nebraska in the fall, but it should be sought at that time.

MEGATHYMIDAE

***Megathymus streckeri texanus* Barnes and McDunnough —
The Giant Texas Skipper**

Megathymidae is a family of large skippers which feed as borers on various species of the genus *Yucca*. Nebraska specimens have been referred to as *M. leussleri* in the older literature. There are records by Leussler from two counties: Valentine, Cherry County, 7 June 1914, and 14 June 1937, with a note that "many specimens were taken in the Sandhills." His specimens are at the Ohio State University.

SUMMARY AND CONCLUSIONS

Faunal and Distributional Data:

During the present study, 167 species of butterflies were noted as occurring within Nebraska. The number of known butterfly species captured in Nebraska ranks fourth only to Colorado's 248 species (Brown *et al.* 1957), California's 208 species (Comstock, 1927), and Wyoming's 194 species (Ferris, 1971). Nebraska also has more species than its southern neighbor, Kansas, where Field (1938) lists 155 taxa, or its eastern neighbor, Iowa, where Christenson (1971) lists 130 taxa. Of course, species may have been added or deleted in some of these states in more current research.

Though Nebraska exhibits a large butterfly fauna, the majority of the species in the fauna are not readily collected. The ecology, and hence the collecting conditions, has changed through the years and this change has been more rapid in recent times. For example, when I collected in the Pine Ridge with Dr. R. W. Dawson, formerly of the University of Nebraska and a collector in these areas in the early 1900's, he mentioned repeatedly that collecting was far less productive than it was in earlier times.

The early collections in the western part of the state were made when the Pine Ridge and the areas around it were sparsely settled and generally undisturbed. There were a number of western montane taxa occurring there that have not since been recorded. These include: *Papilio rutulus*, *Papilio indra*, *Plebejus shasta*, *Neominois ridingsii*, *Melitaea pola*, and *Speyeria atlantis*. Also taken in the early days were species that have been found only in small numbers in recent years. These include: *Parnassius phoebis*, *Neophasia menapia*, *Plebejus acmon*, *Cercyonis oetus*, *Cercyonis meadii*, *Speyeria zerene*, and *Speyeria callippe*. Other western montane species found commonly during both time periods include *Speyeria coronis*, *Oeneis uhleri*, *Speyeria edwardsii*, *Limenitis weidemeyerii*, *Plebejus icarioides*, *Euphydryas anicia*, *Papilio multicaudatus*, *Hesperia pahaska*, and others. Some species, like *Colias alexandra*, *Lycaena rubidus*, and *Mitoura siva* show evidence of becoming more established than was indicated in the early literature. Generally, it seems that those species which have remained common are the species with the least restricted food plants and niches: *Oeneis uhleri* feeding on the common grasses in the canyons, *Limenitis weidemeyerii* on

willow and cottonwood, the speyerids on violets, and *Plebejus icarioides* on the ever present genus *Lupinus*. However, butterflies with more restrictive niches seem to be those no longer established. These include native prairie species *Neominois ridingsii*, *Hesperia ottoe*, and *Melitaea pola*, and *Papilio indra*, a wilderness species occurring in secluded canyons in the Rocky Mountains. Similarly, eastern Nebraska niches for skippers such as *Atrytone arogos* and *Euphyes bimacula* seem to have disappeared.

After the early university expeditions, there was a forty-year gap between periods of thorough collecting in the state. Some species are recorded only from the period of university collections (1890-1920) and then again between 1960 and 1969. This latter period is that of my own intensive collecting in the state. Therefore many of the recent records constitute "rediscoveries" while some early records remain as the only known data on a species. Similarly, a few species are known only from recent records.

It seems desirable to compare the percentage of butterflies collected in the early days to the fauna of recent years. About 18% of the Nebraska butterfly fauna are known only from early records. About 5% are known only from recent records. It may be that early collectors missed the 5% by chance. In all cases, the taxa making up this percentage are known only from one or two specimens which may be "strays," accidental imports, or samples of very small populations. Nearly all of these rare recent discoveries are species whose home ranges are in the extreme western United States. The 18% known only from older records, however, include many whose local residency was once well established. This is a strong indication that a real change in fauna has occurred, and that this change can be related to the fact that some ecological niches have been destroyed. This includes more easily documented changes like that of the native prairie-breeding species mentioned previously, and the disappearance of Pine Ridge representatives of western taxa like *Papilio indra*, *Plebejus shasta*, *Cercyonis meadii*, and *Speyeria atlantis*.

One conclusion these data substantiate is that the number of species of Rhopalocera is decreasing in Nebraska. Experienced collectors within the state report that fewer species are found every year and that density for many species is consistently decreasing. Even in the Pine Ridge, collecting can be very erratic in productivity. Of course, adult behavior is strongly influenced

by local weather, and the emergence of broods is very sensitive to temperature, moisture, and other environmental factors. However, to the field collector the observation of decreasing density year to year seems obvious. Thus, collectors have found species like *Pieris sisymbrii*, *Euphydryas anicia*, and *Oeneis uhleri* common in certain years but apparently absent in others. Likewise, many of the extremely western montane taxa seem to have disappeared completely. After repeated efforts to locate these rarities, one can only conclude that their populations are extinct or only present in isolated, and yet uncollected areas.

The number of species losses should not be considered without discussing species gains in the state. The number of new species records added to the state lists in recent years from the Pine Ridge is small. It includes only *Polygonia hylas*, *Plebejus saepiolus*, *Vanessa caryae*, and *Phyciodes mylitta*. The occurrence of *Vanessa caryae* can be explained by the migratory habits of that genus. Two of the other records might possibly be misidentifications: I have identified certain *Polygonia* as nominate *hylas* on the basis of greenish colorings beneath, and likewise the group of specimens I have referred to the nominate *Phyciodes mylitta* might by some chance be extremely aberrant *P. tharos*. *Plebejus saepiolus* is most likely an oversight by the early collectors. Several of the Plebejinae mentioned in the annotated list occur frequently in the Pine Ridge and suitable biomes for them are not uncommon. As has been noted, the most easily documented cause for the extinction of some populations seems to be niche destruction. Although due mainly to land use, such influences are not entirely negative. In any area, land use affords floral divergence and also new margins. This leads to new arrays of available nectar sources and thus new sympatries between populations. More importantly, it influences the establishment of whole new environments and with them new communities of biota on a large scale. While land use has led to the loss of montane taxa in the west, the planting of new forests eastward has afforded extensions for such taxa as *Mitoura siva*, *Atrytonopsis hiana*, *Euchloe olympia*, and *Papilio multicaudatus*, far to the east. The fact that only the first of these feeds on a woody plant attests to the general influence of these new environments on a plains ecology. However, it is the interplay of many factors such as decreasing density of the entire fauna, new sympatries on both the biome and community level, and the extreme changes in general ecology that effect the total numbers of species losses or gains. The loss of species, however, seems to outweigh species

gains whenever undisturbed areas are cultivated or otherwise "upset."

Two recent studies concerning western Great Plains areas (Johnson, 1971, and F. Martin Brown, in preparation) comment on some effects of these new interactions. They indicate that there is consistent balance of indicative types of biota when general ecological situations begin to "mix." Nebraska as an arbitrary geographic area illustrates the interplay of many of these factors in an interesting way. The general trend is to decreasing densities and to a faunal admixture influenced by continual disturbances of micro-environments. Thus, the loss both in faunal number and the environments supportive of western montane species seems inevitable, along with the disappearance of plains-prairie forms utilizing more restrictive niches, and a possible decrease in frequency of "exotic" transients.

Considering the entire butterfly fauna, nearly every species one would expect to occur in the state has been recorded. Some long-sought species, like *Phyciodes campestris* and *Phyciodes mylitta*, have been found, but only once or twice and only in recent years. Collectors should look not so much for new species records, as for rediscoveries of previously recorded taxa not recently observed. Further, more exact data on density is needed to make accurate observations as to temporal changes. Additions to the state list of species may be made eventually in the Hesperidae (Skippers). *Amblyscirtes nysa* was a new state record in 1969. Some of the Nebraska lepidopterists do not collect skippers, perhaps because their taxonomy is less well known or simply because they are less attractive.

Some Nebraska butterflies are only reported in the southeast and northwest. This can be explained primarily by the extent of collecting in these regions of the state. The east has been quite thoroughly collected by Mr. Spencer, Mr. Froemel, Mr. Kohler, and me. Likewise, much of my collecting has been in the northwest. Only a few weeks were spent collecting in many central areas.

There are a number of species whose distributions deserve further comment. Some extend into areas which were previously unknown for them, at least from published records. These range extensions include: westward extension for *Phyciodes batesii*, *Poanes hobomok*, and *Euptychia cymela*; eastward extension for montane species such as *Speyeria edwardsii*, *Mitoura siva*, *Nymphalis milberti*, *Papilio zelicaon*, and *Lycaena rubidus*; northward extension for *Asterocampa celtis antonia*, *Phyciodes phaon*, and

Atalopedes campestris. There is only one instance of southward extension, that of the single record of *Papilio nitra*.

The occurrence of some rare species in the eastern part of the state is explainable as accidental or chance transients: *Chlosyne lacinia*, *Heliconius charitonius*, *Leptotes marinus*, *Phyciodes vesta*, *Phyciodes picta*, and *Mestra amymone*. These species commonly journey into northern states, perhaps following the route of the Missouri River, or in response to the strong winds that blow northward across the plains in late summer. Their records usually indicate the resident location of lepidopterists rather than indicating the biological or ecological preferences of the butterflies. Similar instances of transients occurred at the time of early collections when butterflies like *Papilio palamedes*, *Appias drusilla*, and *Kricogonia lyside* were recorded.

In many taxonomic groups of Nebraska butterflies, a distinctive separation can be made between "mountain-dwelling forms" in the west, and "plains-prairie forms" in the east. For example, *Papilio glaucus* occurs in the eastern part of the state and *Papilio multicaudatus* in the west. Likewise, *Limenitis astyanax* occurs in the east and *Limenitis weidemeyerii* in the west. The distribution of species representing the genus *Speyeria* (the fritillaries) is also distinctive. Apparently these groupings are physically separated by the Sandhills barrier, as can be noted from the accompanying distribution maps. The Sandhills is an area of mixed-prairie often lacking any significant occurrence of trees or shrubs.

There are only two instances of reported Nebraska species which are evidently in error. These are *Pieris napi* and *Papilio bairdii*. I have not seen the specimens on which the records are based. However, the former species is a high elevation Rocky Mountain species, while the latter is a form rarely found east of the continental divide. There is another species reported as occurring in Nebraska that I have not been able to verify. This is *Mitoura gryneus* as reported in Klots (1951). This species is not represented in any local collection, nor has it appeared through the searching of appropriate biomes in eastern Nebraska. I have commented on factors involving apparent hybridization in the food plant of this genus (Johnson, 1972) and the eastward extension of *M. siva*. No doubt any *Mitoura gryneus* populations occurring in the state are involved with this same phenomenon. Concerning the early reports of many western montane taxa purported to occur on the plains, one must always use caution. Christenson, in his study of Iowa butterflies (1971), reports a

number of these early citations which are extremely problematic in verifying. Reservation is always wise concerning these records. The rest of the Nebraska records have been deemed valid either by my personal examining, that of a specialist, or the high probability of their occurrence and ease of determination by non-specialists.

A few of the species recorded in Nebraska are known from only one specimen. These are clearly transients, and include *Heliconius charitonius*, *Appias drusilla*, and possibly *Amblyscirtes nysa*. Others, like *Plebejus saepiolus*, are extreme western-montane taxa. A high incidence of single records occurs in the Hesperidae (Skippers). No doubt this is because they have been pursued the least by collectors. Considering butterflies in general, some of the "rare" species in Nebraska are extremely local and occur only locally throughout their North American ranges. Examples are *Limenitis archippus*, *Anaea andria*, *Pieris sisymbrii*, *Atrytone arogos*, and *Euphyes bimacula*.

Nebraska as an Ecotone Between "Eastern" and "Western" Biota:

Much has been written about the uniqueness of Nebraska as an ecotone between "eastern" and "western" biota. Several writers have testified to the geographical sympatry of plants in Nebraska (Nixon, 1967; Tolstead, 1947; Wells, 1965). Likewise, the butterfly fauna has often been remarked as one of an interesting admixture of species (Cary, 1901; Leussler, 1938, 1939; Johnson and Nixon, 1967), and is a major thesis of this work.

In considering the east-west ecotonal influence in Nebraska, it is best to begin with reference to the flora. The vegetation of the state exhibits a broad transition from the deciduous forest in the Missouri Valley, through tall grass and mixed prairie, to coniferous forest in the west. The most distinct change is in the west where the wooded escarpments rise abruptly above the plains, and altitudes range up to 5000 feet. Such areas occur in the northwest and southwest "panhandle." The effect of this biome on the Nebraska flora is interesting. These areas have become harbors for plants which characterize coniferous biomes in western and northern North America. Nixon (1967) points out that within the western pine forests can be found various botanical oddities. For instance, here may be found woody species characteristic of the north, such as *Populus tremuloides* Michx., *Amelancier alnifolia* Nutt., *Cornus stolonifera* Michx., and *Shepherdia canadensis* (L.) Nels., as well as *Koleria cristata* (L.) Pers., *Stipa comata* Trin. and Rupr., *Stipa viridula* Trin., *Agropyron smithii* Rydb., and *Elymus canadensis* L. *Pinus*

ponderosa Laws. is the dominant plant and is characteristic of the Rocky Mountains. Another Rocky Mountain species is also present: Mountain mahogany (*Cercocarpus montanus* Raf.). Species of *Artemisia* and *Mammillaria*, and the ever-present *Yucca glauca* Nutt. represent the Great Basin influence (Nixon, 1967). Others could be mentioned, from north, south, east, and west. These coniferous forest biomes extend eastward along the northern water courses, well past the midline of the state, and juniper-covered bluffs occur in many parts of the western counties. These all tend to support a number of butterfly species which are not characteristic of the surrounding plains.

Likewise, ornithologists in Nebraska are familiar with the variety of western birds occupying niches in the western part of the state. Birds like the Mountain Bluebird (*Sialia currucoides*), Pinon Jay (*Cyanocephalus cyanocephalus*), Western Tanager (*Paranga ludoviciana*), Bullock's Oriole (*Icturus bullocki*), and Townsend's Solitaire (*Myadestes townsendi*) occur with varying frequency in the escarpments.

Lepidopterists (Cary, 1901; Johnson and Nixon, 1967) noticed the graduation from typically eastern to western species as one moves westward in the state. When the coniferous escarpments are reached, one begins to find butterflies such as *Colias alexandra*, *Pieris sisymbrii*, *Limenitis weidemeyerii*, *Hesperia pahaska*, *Oeneis uhleri*, *Euphydryas anicia*, *Papilio multicaudatus*, and many others typical of the western regions of North America. Also, range extensions of western species such as *Limenitis weidemeyerii*, *Mitoura siva*, and *Papilio multicaudatus* occur in some cases east of the one-hundredth meridian. The Rocky Mountain taxa *Neominois ridingsii* and *Papilio indra* once extended into the high altitude grasslands of the southern "pan-handle," and *Mitoura siva* has become established on the juniper-covered bluffs of the southwestern counties.

To illustrate the biogeographical sympatry of butterflies in the Pine Ridge, simple faunal resemblance statistics can be utilized. Using a formula attributed to P. Jaccard (Long, 1963) where C is total taxa in common, and N_1 and N_2 are the number of taxa in each sample, a simple percentage of faunal resemblance can be calculated.

$$\text{percent resemblance} = \frac{C (100)}{N_1 + N_2 - C}$$

Using this formula, the faunal resemblance between the Pine

Ridge and the Black Hills of South Dakota is 60%. Likewise, the percent resemblance between the Pine Ridge and the Nebraska plains is 55%. But the affinity between the Black Hills fauna and that of the Nebraska plains is only 28%, indicating that the Pine Ridge is an area of distributional overlap for a large number of species of butterflies. The sample list for the Black Hills was taken from the literature and personal correspondence. In the Pine Ridge a large number of both "eastern" and "western" types of butterflies occur, and it is the area in which many species reach the western or eastern limit of their respective ranges. The situation is similar in the Wildcat Range, with montane species occurring eastward until no semblance of coniferous forest is left and the buttes give way to the plains.

Nearly thirty species of butterflies occur in the Pine Ridge (and similarly in the Wildcat Range) which are not listed in Klots' (1951) *Field Guide*. Lepidopterists generally consider this book as treating the North American butterfly fauna east of the one-hundredth meridian. This geographic line is nearly a perfect mid-line for Nebraska. Hence, Nebraska's large fauna is largely attributable to the montane influence in the west, coupled with the presence of many eastern butterflies in the eastern counties which are characteristic of Kansas, Missouri, Iowa, and eastern South Dakota. The phenomenon of interesting biogeographical overlapping of species is well illustrated in certain areas of Nebraska in many groups of organisms. Similar conditions are found in many of the Great Plains states and deserve more thorough study.

Outgrowths of the Present Study:

Several possible outgrowths of this project have been mentioned in the annotated list. The taxonomic problems involving *Everes comyntas* and *Everes amyntula* have been investigated (Downey and Christenson, 1970), but problems remain with western Great Plains representatives of *Pieris sisymbrii*, *Lethe eurydice*, *Boloria selene*, *Asterocampa celtis*, and *Cercyonis* ssp.

More research is needed on food plant relationships in the state, particularly those of the western *Speyeria*. The effect of lower altitudes on voltinism of montane species needs to be investigated. In this case, the occurrence of longer broods in the fritillaries (*Speyeria* ssp.) invites interest.

More complete studies of the distributions of *Lycaena xanthoides*, *Polygonia satyrus*, *Polygonia comma*, *Papilio multicaudatus*, *Lycaena rubidus*, *Lethe eurydice*, *Mitoura siva*, and others could provide important biological data as to evolutionary and

ecological relationships. The role of the Sandhills region as an ecological barrier needs to be investigated. Density of species occurrence should also be an important aspect of study since it will permit conclusions on changes in population with time. Nebraska also affords many areas in which the phenomena of new sympatries and distributional overlapping can be observed and investigated.

Also, the present study would indicate the need for further taxonomic and distributional studies of the entire faunas of areas like the Black Hills of South Dakota, and the states of North Dakota and Montana.

Research on all of these topics is important to the general knowledge of the biology of the middle United States. Surely the study of specific groups such as the butterflies will provide a basis on which can be built our general ecological knowledge of the region.

CHECKLIST OF THE BUTTERFLIES OF NEBRASKA

SATYRIDAE

Satyrinae

1. *Oeneis uhleri uhleri* (Reakirt)
2. *Cercyonis oetus oetus* (Boisduval)
3. *Cercyonis meadii* (Edwards)
4. *Cercyonis pegala* (Fabricius)
5. *Neominois ridingsii ridingsii* (Edwards)
6. *Coenonympha ochracea ochracea* Edwards
7. *Euptychia cymela* (Cramer)

Lethinae

8. *Lethe eurydice* (Johannson)
9. *Lethe portlandia* (Fabricius)

DANAIDAE

Danainae

10. *Danaus (Tasitia) gilippus* (Cramer)
11. *Danaus (D.) plexippus plexippus* (Linnaeus)

NYMPHALIDAE

Heliconiinae

12. *Agraulis vanillae* (Linnaeus)
13. *Dryas julia* (Fabricius)
14. *Heliconius charitonius* (Linnaeus)

Argynninae

15. *Euptoieta claudia* (Cramer)
16. *Speyeria* (S.) *aphrodite* (Fabricius)
17. *Speyeria* (S.) *cybele cybele* (Fabricius)
18. *Speyeria* (S.) *atlantis* (Edwards)
19. *Speyeria* (S.) *callippe meadii* (Edwards)
20. *Speyeria* (S.) *zerene* (Boisduval)
21. *Speyeria* (S.) *coronis* (Behr)
22. *Speyeria* (S.) *edwardsii* (Reakirt)
23. *Speyeria* (S.) *idalia* (Drury)
24. *Boloria* (Clossiana) *selene* (Denis and Schiffermuller)

Melitaeinae

25. *Euphydryas anicia bernadetta* Leussler
26. *Melitaea* (Microtia) *pola* Boisduval
27. *Melitaea* (M.) *ismeria carlota* (Reakirt)
28. *Melitaea* (M.) *nycteis drusius* (Edwards)
29. *Phyciodes* (Phyciodes) *vesta* (Edwards)
30. *Phyciodes* (P.) *picta* Edwards
31. *Phyciodes* (P.) *campestris camillus* Edwards
32. *Phyciodes* (P.) *mylitta* (Edwards)
33. *Phyciodes* (P.) *phaon* (Edwards)
34. *Phyciodes* (P.) *batesii* (Reakirt)
35. *Phyciodes* (P.) *tharos tharos* (Drury)
36. *Phyciodes* (Tritanassa) *texanna* (Edwards)
37. *Chlosyne lacinia adjutrix* Scudder

Nymphalinae

38. *Polygonia progne* (Cramer)
39. *Polygonia zephyrus* (Edwards)
40. *Polygonia hylas* (Edwards)
41. *Polygonia satyrus* (Edwards)
42. *Polygonia comma* (Harris)
43. *Polygonia interrigrationis* (Fabricius)
44. *Nymphalis antiopa* (Linnaeus)
45. *Nymphalis milberti* (Godart)
46. *Nymphalis vaui-album j-album* (Boisduval and LeConte)

Vanessinae

47. *Junonia coenia coenia* (Huebner)
48. *Vanessa caryae* Huebner
49. *Vanessa cardui* (Linnaeus)
50. *Vanessa virginiensis* (Drury)
51. *Vanessa atalanta* (Linnaeus)

Limenitidinae

52. *Limenitis weidemeyerii* (Edwards)
53. *Limenitis archippus* (Cramer)
54. *Limenitis arthemis astyanax* (Fabricius)

Eurytelinae

55. *Mestra amymone* (Menetries)

Apaturinae

56. *Asterocampa clyton* (Boisduval and LeConte)57. *Asterocampa celtis* (Boisduval and LeConte)

Charaxinae

58. *Anaea andria* Scudder

LIBYTHEIDAE

Libytheinae

59. *Libytheana bachmanni* (Kirtland)

LYCAENIDAE

Plebejinae

60. *Celastrina argiolus* (Linnaeus)61. *Glaucopsyche lygdamus oro* Scudder62. *Scolitantides pius* (Boisduval)63. *Everes comyntas* (Godart)64. *Plebejus (Icaricia) acmon* (Westwood)65. *Plebejus (I.) shasta minnehaha* (Scudder)66. *Plebejus (I.) icarioides lycea* (Edwards)67. *Plebejus (Plebejus) saepiolus* (Boisduval)68. *Lycaeides melissa* (Edwards)69. *Hemiargus isola* (Reakirt)70. *Leptotes marina* (Reakirt)71. *Brephidium exilis exilis* (Boisduval)

Lycaeninae

72. *Lycaena phlaeas americana* Harris73. *Lycaena dorcas dorcas* Kirby74. *Lycaena rubidus* Behr75. *Lycaena xanthoides dione* Scudder76. *Lycaena thoe* Guerin

Gerydinae

77. *Feniseca tarquinius* (Fabricius)

Theclinae

78. *Strymon liparops aliparops* Michener and dos Passos79. *Strymon falacer* (Godart)80. *Strymon edwardsii* (Grote and Robinson)81. *Strymon acadica montanensis* Watson and Comstock82. *Strymon titus titus* (Fabricius)83. *Strymon melinus* (Huebner)84. *Strymon cecrops* (Fabricius)85. *Incisalia niphon* (Huebner)86. *Incisalia eryphon* (Boisduval)87. *Incisalia henrici* (Grote and Robinson)88. *Mitoura siva* (Edwards)

PIERIDAE

Euchloeinae

89. *Euchloe olympia rosa* (Edwards)90. *Euchloe ausonides coloradensis* (Edwards)

91. *Anthocaris genutia* (Fabricius)
Coliadinae
92. *Nathalis iole* Boisduval
93. *Eurema nicippe nicippe* (Cramer)
94. *Eurema lisa lisa* Boisduval and LeConte
95. *Eurema mexicana* (Boisduval)
96. *Kricogonia lyside* (Godart)
97. *Phoebis sennae eubule* (Linnaeus)
98. *Phoebis agarithe* (Boisduval)
99. *Anteos maerula* (Fabricius)
100. *Colias* (Zerene) *caesonia caesonia* (Stoll)
101. *Colias alexandra* Edwards
102. *Colias philodice* Godart
103. *Colias eurytheme* Boisduval
Pierinae
104. *Pieris rapae* (Linnaeus)
105. *Pieris protodice* Boisduval and LeConte
106. *Pieris sisymbrii* Boisduval
107. *Appias drusilla* (Cramer)
108. *Neophasia menapia* (Felder and Felder)

PAPILIONIDAE

- Papilioninae
109. *Graphium marcellus* (Cramer)
110. *Papilio palamedes* Drury
111. *Papilio troilus troilus* Linnaeus
112. *Papilio multicaudatus* Kirby
113. *Papilio rutulus* Boisduval
114. *Papilio glaucus* Linnaeus
115. *Papilio cresphontes* Cramer
116. *Papilio indra* Reakirt
117. *Papilio zelicaon* Lucas
118. *Papilio nitra* Edwards
119. *Papilio polyxenes asterius* Stoll
120. *Battus philenor* (Linnaeus)
Parnassinae
121. *Parnassius phoebis sayii* Edwards

HESPERIIDAE

- Pyrginae
122. *Epargyreus clarus* (Cramer)
123. *Thorybes pylades* (Scudder)
124. *Thorybes bathyllus* (Abbot and Smith)
125. *Staphylus mazana hayhurstii* (Edwards)
126. *Erynnis juvenalis* (Fabricius)
127. *Erynnis horatius* (Scudder and Burgess)
128. *Erynnis martialis* (Scudder and Burgess)
129. *Erynnis zarruco funeralis* (Scudder and Burgess)

130. *Erynnis lucilius afranius* (Scudder and Burgess)
131. *Erynnis persius* (Scudder and Burgess)
132. *Erynnis brizo* (Boisduval and LeConte)
133. *Pyrgus communis* (Grote)
134. *Pholisora catullus* (Fabricius)

Hesperiinae

135. *Ancyloxipha numitor* (Fabricius)
136. *Oarisma garita* (Reakirt)
137. *Oarisma powesheik* (Parker)
138. *Hylephila phyleus* (Drury)
139. *Yvretta rhesus* (Edwards)
140. *Hesperia attalus* (Edwards)
141. *Hesperia ottoe* Edwards
142. *Hesperia pawnee* Dodge
143. *Hesperia pahaska pahaska* Leussler
144. *Hesperia comma colorado* (Scudder)
145. *Hesperia uncus* (Edwards)
146. *Polites mystic dacotah* (Edwards)
147. *Polites manataaqua* (Scudder)
148. *Polites themistocles* (Latreille)
149. *Polites peckius* (Kirby)
150. *Wallengrenia otho egeremet* (Scudder)
151. *Pompeius verna* (Edwards)
152. *Atalopedes campestris* (Boisduval)
153. *Atrytone delaware delaware* (Edwards)
154. *Atrytone arogos* (Boisduval and LeConte)
155. *Poanes taxiles taxiles* (Edwards)
156. *Poanes zabulon* (Boisduval and LeConte)
157. *Poanes hobomok* (Harris)
158. *Euphyes vestris vestris* (Boisduval)
159. *Euphyes bimacula* (Grote and Robinson)
160. *Euphyes conspicua* (Edwards)
161. *Euphyes dion* (Edwards)
162. *Atrytonopsis hiana* (Scudder)
163. *Amblyscirtes vialis* (Edwards)
164. *Amblyscirtes nysa* Edwards
165. *Amblyscirtes osleri* (Skinner)
166. *Lerodea eufala* (Edwards)

MEGATHYMIDAE

167. *Megathymus streckeri texanus* Barnes and McDunnough

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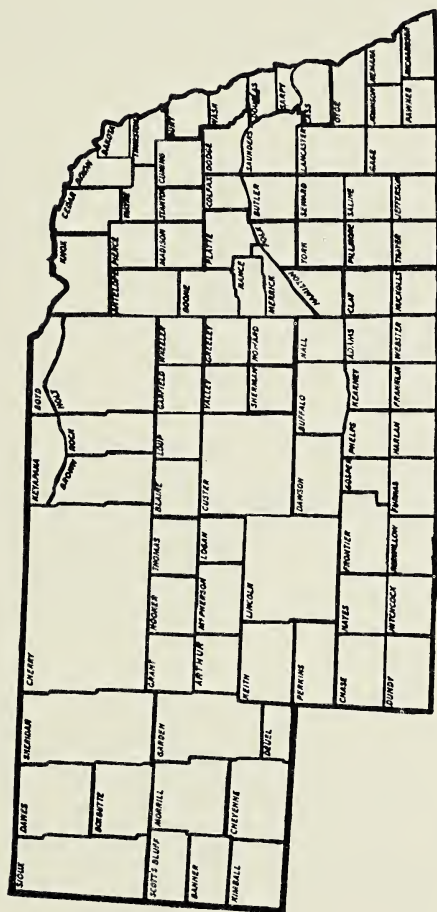
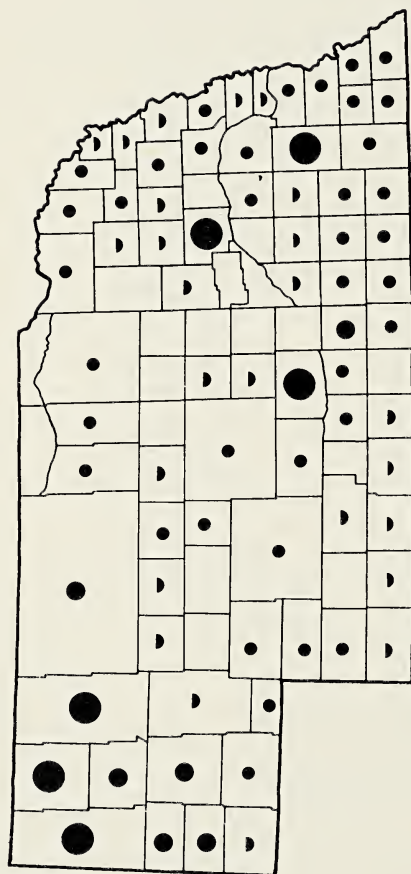
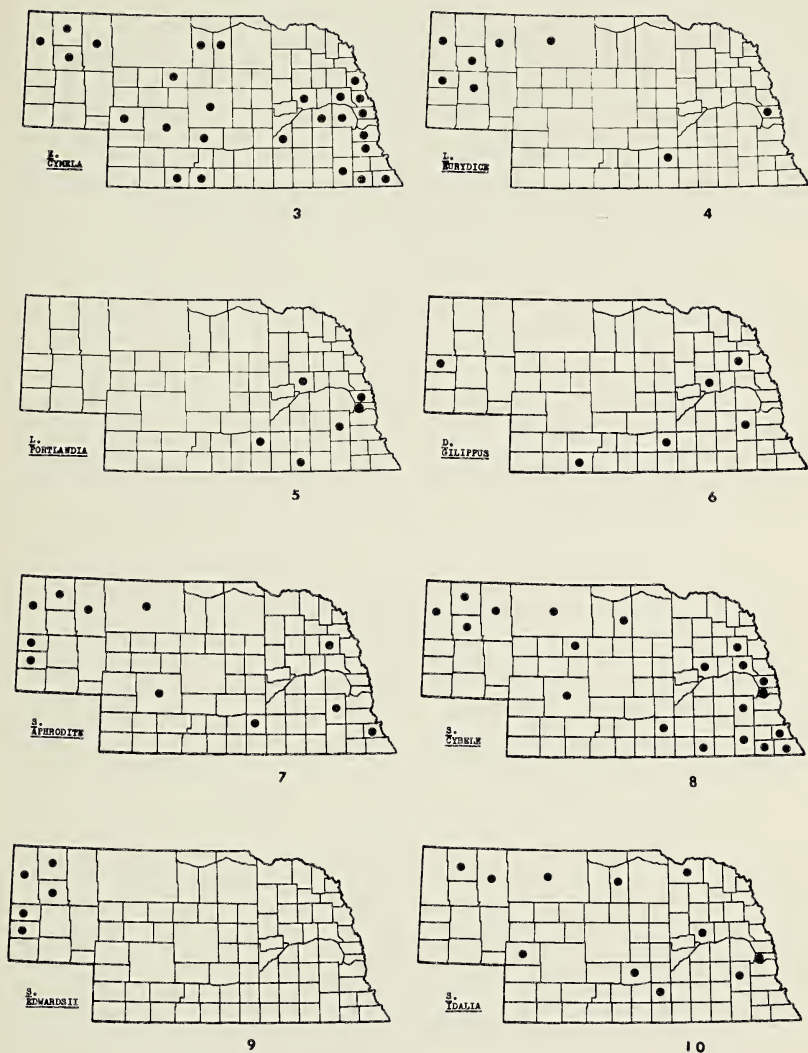


Fig. 1.—Map of Nebraska with counties indicated.



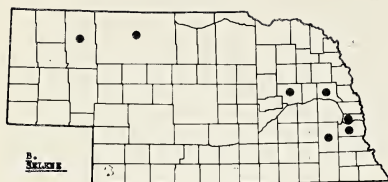
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Fig. 2.—Relative amounts of recent butterfly collecting in Nebraska counties. Large dot: Extensive collecting since 1960 by Nebraska lepidopterists. Medium dot: Frequent collecting since 1960 by Nebraska lepidopterists. Small dot: Collected by Johnson and Running in 1969. Half circle: Recent butterfly records exist from these counties but no concerted effort has been made to collect in them.

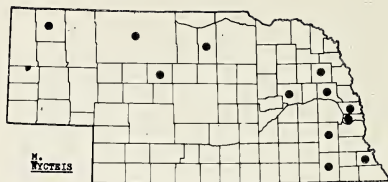


Distribution of Selected Butterflies in Nebraska

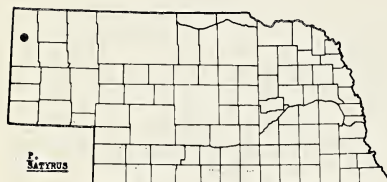
Fig. 3.—*Euptychia cymela* (Cramer)Fig. 4.—*Lethe eurydice* (Johannson)Fig. 5.—*Lethe portlandia* (Fabricius)Fig. 6.—*Danaus gilippus* (Cramer)Fig. 7.—*Speyeria aphrodite* (Fabricius)Fig. 8.—*Speyeria cybele* (Fabricius)Fig. 9.—*Speyeria edwardsii* (Reakirt)Fig. 10.—*Speyeria idalia* (Drury)



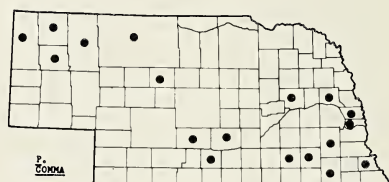
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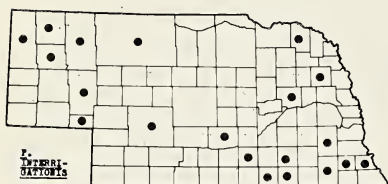
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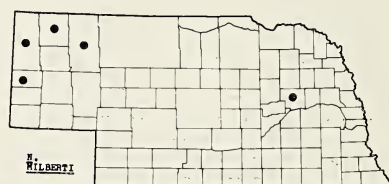
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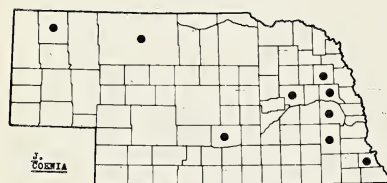
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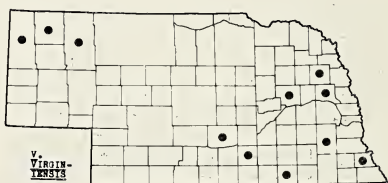
15



16



17



18

Distribution of Selected Butterflies in Nebraska

Fig. 11.—*Boloria selene* (Denis and Schiffermüller)

Fig. 12.—*Melitaea nycteis* (Doubleday)

Fig. 13.—*Polygonia satyrus* (Edwards)

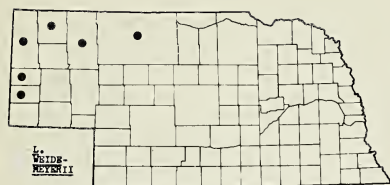
Fig. 14.—*Polygonia comma* (Harris)

Fig. 15.—*Polygonia interragationis* (Fabricius)

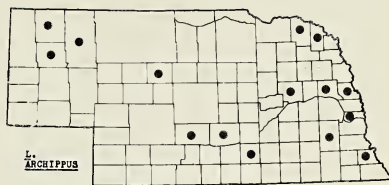
Fig. 16.—*Nymphalis milberti* (Godart)

Fig. 17.—*Junonia coenia* (Huebner)

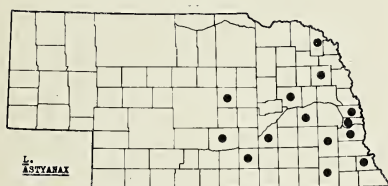
Fig. 18.—*Vanessa virginiensis* (Drury)



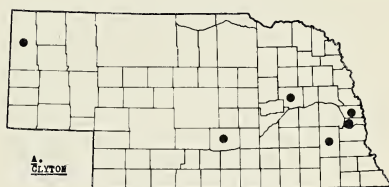
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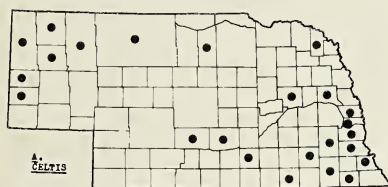
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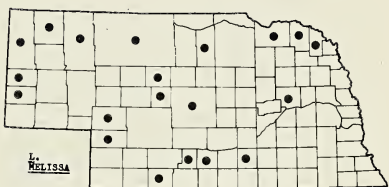
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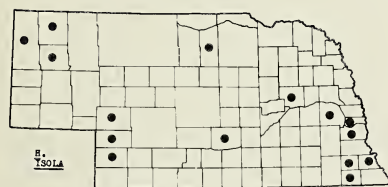
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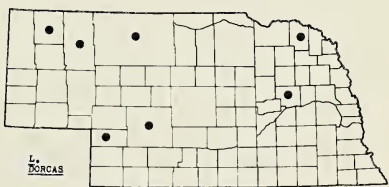
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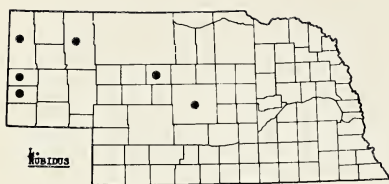
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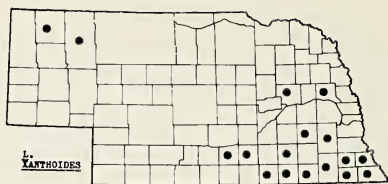
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Distribution of Selected Butterflies in Nebraska

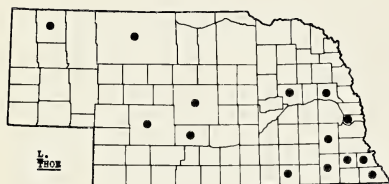
Fig. 19.—*Limenitis weidemeyerii* (Edwards)Fig. 20.—*Limenitis archippus* (Cramer)Fig. 21.—*Limenitis astyanax* (Fabricius)Fig. 22.—*Asterocampa clyton* (Boisduval and Le Conte)Fig. 23.—*Asterocampa celtis* (Boisduval and Le Conte)Fig. 24.—*Lycaeides melissa* (Edwards)Fig. 25.—*Hemiargus isola* (Reakirt)Fig. 26.—*Lycaena dorcas* Kirby



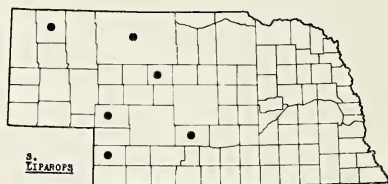
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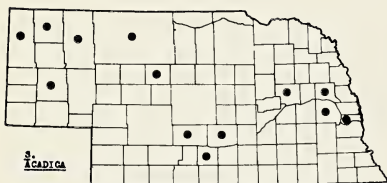
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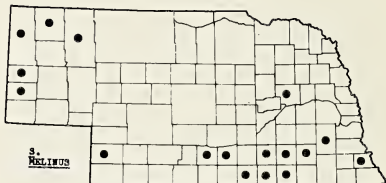
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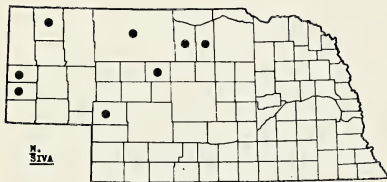
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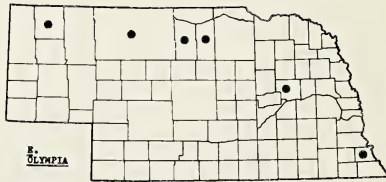
31



32



33



34

Distribution of Selected Butterflies in Nebraska

Fig. 27.—*Lycaena rubidus* Behr

Fig. 28.—*Lycaena xanthoides* Boisduval

Fig. 29.—*Lycaena thoe* Guerin

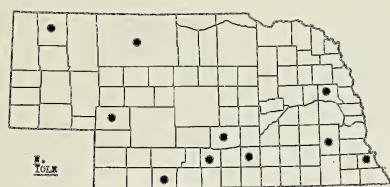
Fig. 30.—*Strymon liparops* (LeConte)

Fig. 31.—*Strymon acadica* (Edwards)

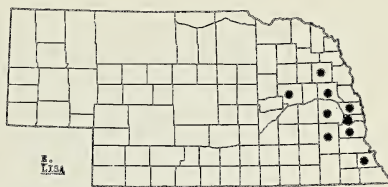
Fig. 32.—*Strymon melinus* (Huebner)

Fig. 33.—*Mitoura siva* (Edwards)

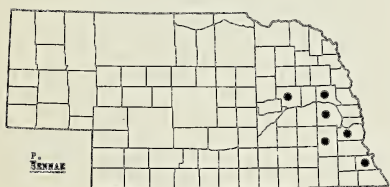
Fig. 34.—*Euphonia olympia* (Edwards)



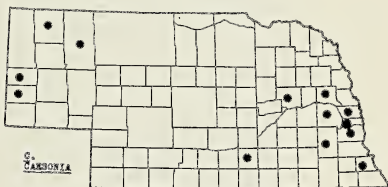
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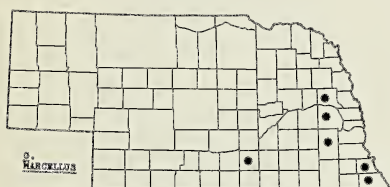
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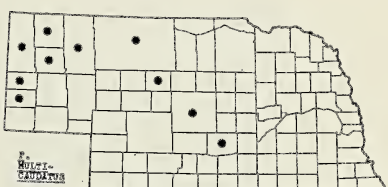
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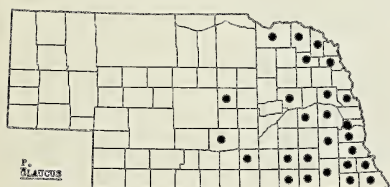
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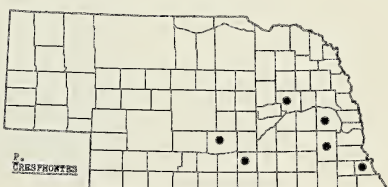
39



40



41



42

Distribution of Selected Butterflies in Nebraska

Fig. 35.—*Nathalis iole* Boisduval

Fig. 36.—*Eurema lisa* Boisduval and LeConte

Fig. 37.—*Phoebis sennae* (Linnaeus)

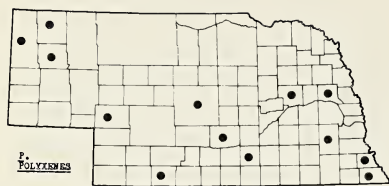
Fig. 38.—*Colias caesonja* (Stoll)

Fig. 39.—*Graphium marcellus* (Cramer)

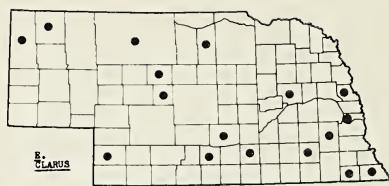
Fig. 40.—*Papilio multicaudatus* Kirby

Fig. 41.—*Papilio glaucus* Linnaeus

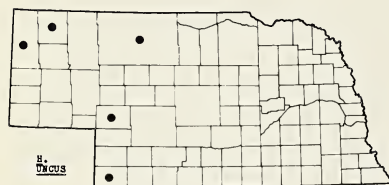
Fig. 42.—*Papilio cressphontes* Cramer



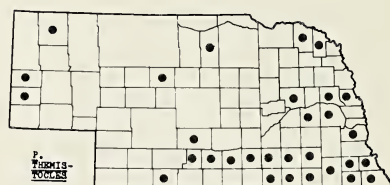
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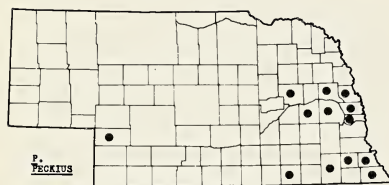
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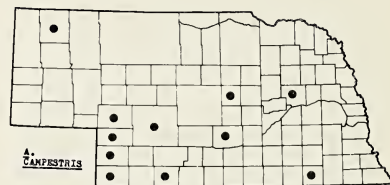
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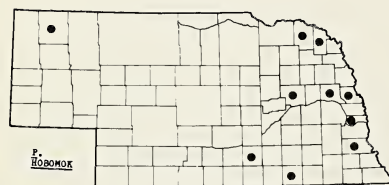
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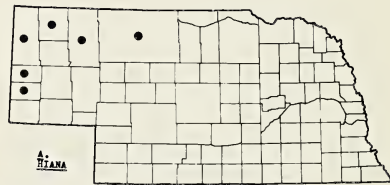
47



48



49



50

Distribution of Selected Butterflies in Nebraska

Fig. 43.—*Papilio polyxenes* Fabricius

Fig. 44.—*Epargyreus clarus* (Cramer)

Fig. 45.—*Hesperia uncus* (Edwards)

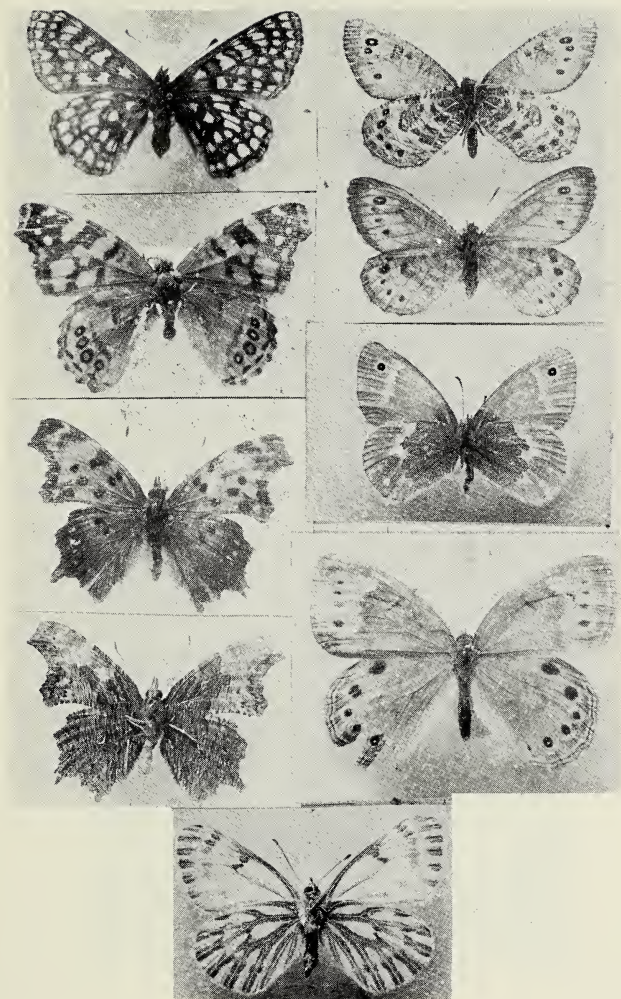
Fig. 46.—*Polites themistocles* (Latreille)

Fig. 47.—*Polites peckius* (Kirby)

Fig. 48.—*Atalopedes campestris* (Boisduval)

Fig. 49.—*Poanes hobomok* (Harris)

Fig. 50.—*Atrytonopsis hiana* (Scudder)



LEGEND

Euphydryas anicia bernadetta,
45mm.

Vanessa caryae, 48mm.

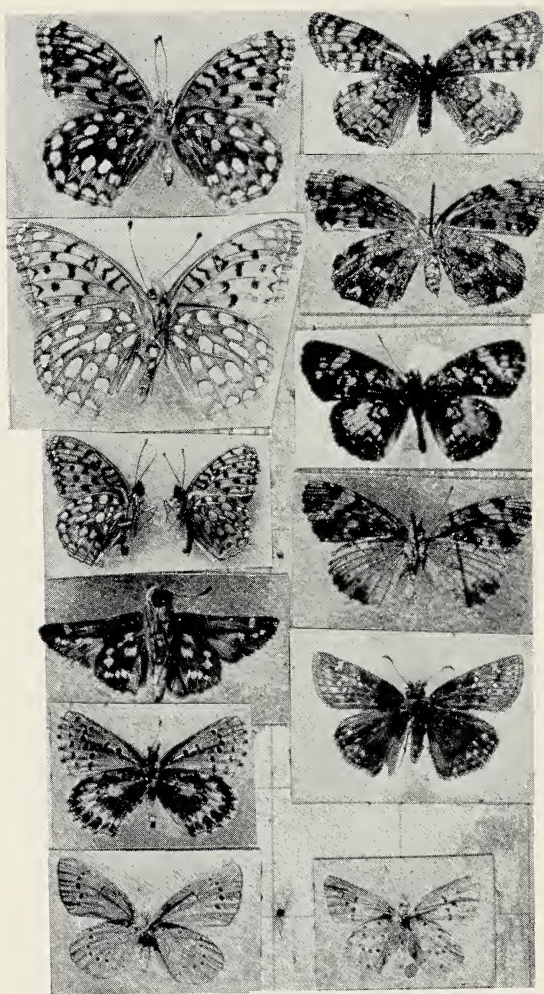
Polygonia hylas, upper, 44mm.
same, lower, 44mm.

Oeneis uhleri uhleri, lower 45mm.
same, upper, 45mm.

Coenonympha ochracea ochracea,
upper, 30 mm.

Lethe eurydice, upper 45mm.

Pieris sisymbrii,
under, 37mm.



LEGEND

Speyeria aphrodite ethne,
under, 63mm.

Speyeria callippe meadii,
under, 61mm.

left, *Speyeria coronis*, under,
29mm. ($\frac{1}{2}$)

right, *Speyeria zerene*, under,
25mm. ($\frac{1}{2}$)

Hesperia pahaska, under, 34mm.

Scolitantides piasus, under, 29mm.

Glaucopsyche lygdamas ssp.,
under, 29mm.

Phyciodes mylitta, upper, 35 mm.
same, lower.

Phyciodes batesii, upper, 32mm.
same, lower.

Erynnis lucilius afranius, 35 mm.

Plebejus saepiolus, under, 30 mm.

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IN THIS ISSUE

THE BUTTERFLIES OF NEBRASKA

KURT JOHNSON

1

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THE JOURNAL
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A POPULATION STUDY OF
THE NEOTROPICAL NYMPHALID
BUTTERFLY, *ANARTIA AMALTHEA*,
IN ECUADOR

MICHAEL K. FOSDICK

Colorado College, Colorado Springs, Colorado 80903

THE POPULATION BIOLOGY of the southern Neotropical butterfly *Anartia amalthea* (Nymphalidae, Nymphalinae) has not been previously described. However, some work has been done on its northern tropical allied form, *A. fatima* (Emmel, 1972). The present study of *A. amalthea* will allow for initial comparisons to be made between this species and its northern allied form. Reported here are data obtained on population size, intrapopulation movement, and social interaction in a population of *A. amalthea* located in the eastern lowlands of Ecuador.

MATERIALS AND METHODS

Anartia amalthea inhabits rain forest areas ranging from the lowlands of Panama southward throughout the lowlands of South America to southern Brazil (Godman and Salvin, 1879). It is a deliberate-flying, medium-sized butterfly with a wingspread of approximately 40 mm. The ground color of the wings dorsally is dark brown to black and there are usually three red spots of variable size located at the basal portion of the hindwing. Both sexes bear a red (male) or orange (female) median band running across both the forewing and hindwing with a series of white spots (usually twelve) near the apex and postmedian area of the forewing (Fig. 1-4). The ventral side is almost identical in pattern but much lighter in general aspect. In many cases the sex of the individual was difficult to determine strictly by color characteristics. Despite the abundance of the species throughout the neotropics, the life history and larval food plants, undoubtedly weedy second-growth species, remain unknown (Comstock and Vazquez, 1961). However, in the present study, adult *A. amalthea* were found to be feeding on the mint *Hyptis mutabilis* and a weedy species from the genus *Sida* (Malvaceae).



Fig. 1-4.—Photographs of *Anartia amalthea*: (1) Male dorsal surface, (2) female dorsal surface, (3) male ventral surface, and (4) female ventral surface.

The characteristic flight pattern of *A. amalthea* is generally casual. Leisurely, slow-wingbeat flight up to approximately 2 meters above ground level was observed as well as erratic fast flight up to 5 meters above ground level. Once alighted on a surface, usually a wide grass blade or leaf, *A. amalthea* will spread its wings and orient itself toward the sun. With an overcast sky this species, when perched, will spread its wings and orient in a random direction. This behavior has a double purpose: (1) *A. amalthea* can thermoregulate and (2) colors are exposed for possible sexual attraction.

The locality of the study site was a second-growth area within the borders of a missionary station at Limoncocha, situated in the eastern Amazonian rain forest of Ecuador at an elevation of 275 meters (latitude 0.4°S, longitude 77.5°W).

The general vegetational formation of the study site was wet tropical rain forest in an intermediate stage of second-growth recovery. The study area was a vegetational "island" 30 by 35 meters surrounded by open fields on three sides and a road to the north (Fig. 5). *Anartia amalthea* were abundant in this area as well as various species of *Euptychia* (Satyridae).

Approximately half of the study area contained grasses and weeds from 0.1 to 2 meters in height and the other half contained bushes and trees from 2 to 7 meters in height. The butterflies flew above the grass as well as up and over the high bushes. Second-growth plants found in the study area were: *Papaya*, young *Balsa*, Piperaceae, *Heliconia* (Musaceae) plants, Convolvulaceae, and other weedy second-growth species.

The daily weather here was variable. According to weather records kept by the personnel stationed at Limoncocha, temperatures very seldom exceed 90°F; temperatures during the study period ranged between 75° and 90°F. The relative humidity near ground level was relatively constant around 70%, with the possibility of rain any time of the day or night. The sun was shining constantly only one morning, September 10, during the entire study period; on the other dates the sky was either overcast or partly cloudy.

Aside from occasional afternoon observations, most of the research was carried out during the morning between 0830 and 1200 hours. This period was inclusive of the peak flight activity which fell between 1030 and 1200 hours on a sunny day. When overcast, there seemed to be no special time of peak flight activity. *Anartia amalthea* were even observed to be active in a moderate rain. Flight activity would begin around 0600 hours and last until 1800 hours.

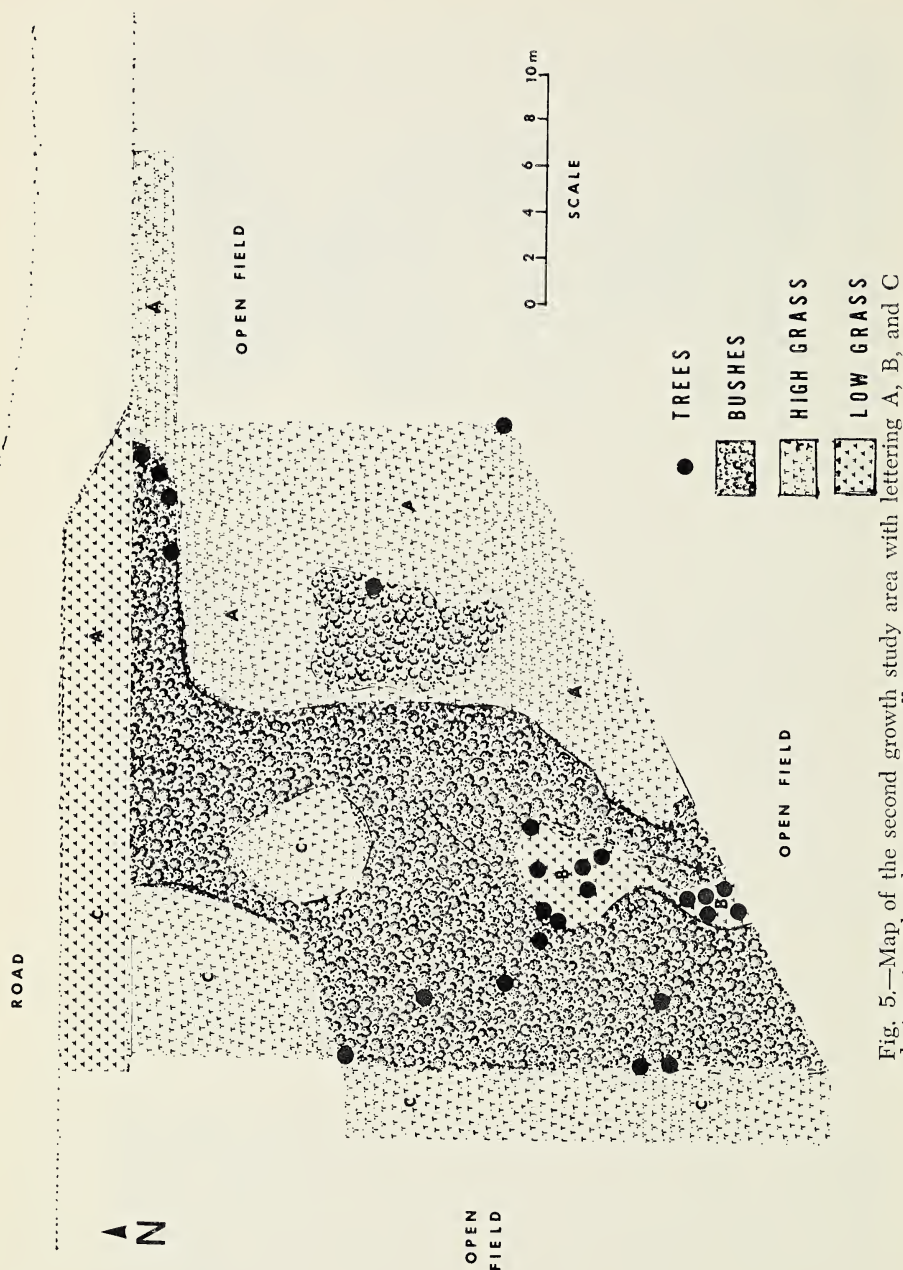


Fig. 5.—Map of the second growth study area with lettering A, B, and C designating the three separate collecting areas.

A capture-mark-release-recapture program to determine population size by three applicable standard methods was initiated on the afternoon of September 5, 1972 and continued until the morning of September 12, 1972. Specimens were marked on the ventral surface of the right wing using a blue Magic Marker pen. Marking was done by coloring in white spots on the wing using a 1-2-4-7-10 coding system (modified from a system first used by Ehrlich and Davidson, 1961) (Fig. 6). Specimens were captured in three separate areas designated A, B, and C (Fig. 5), which are divisions of the entire study area. The purpose of this division was to determine the extent of intrapopulation movement. Each day, work was begun at area A and from there extended to B and C. Collecting time in each area was relatively proportional to the size of the area. In area A collecting time averaged one and a half hours, area B averaged half an hour, and area C averaged one hour. After capture the specimens were marked and put into a holding bag of netting until the allotted capture time had expired. The specimens were released at this time in the area in which they were captured. Recapture procedures also followed the previously stated order.

Several female specimens were marked by coloring in the orange band on the dorsal side of the wing with a red Magic Marker pen. By this procedure the females' band was identical in color to the males. Observations were carried out on these marked females to determine the males' reactions.

RESULTS

The capture-recapture data resulting from this work are summarized by the trellis diagram in Figure 7. Estimates of population size (see Table 1) were obtained with these data using three statistical methods.

1. *Modified Lincoln Index* (Bailey, 1951):

$$P_1 = \frac{(N_2 + 1) M_1}{R_2 + 1}$$

where P_1 = population size on day one,
 M_1 = the number marked on day one,
 N_2 = the total number of captures on day two,
and
 R_2 = the number of recaptures on day two

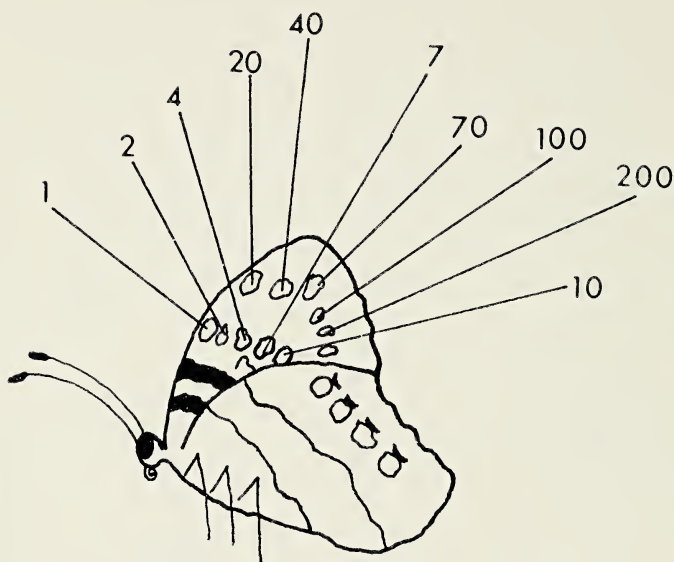


Fig. 6.—*Anartia amalthea*: ventral surface, showing ocellation pattern and coding system.

2. Bailey's *Triple Catch Method* (Bailey, 1952):

$$P_2 = \frac{M_2 N_2 R_{3_1}}{R_{2_1} R_{3_2}}$$

where P_2 = population size on day two,

M_2 = number of individuals marked on day two,

R_{3_1} = number of recaptures taken on day three
and marked on day one,

R_{2_1} = number of recaptures taken on day two and
marked on day one, and

R_{3_2} = number or recaptures taken on day three
and marked on day two



Fig. 7.—Treillis diagram summarizing capture-recapture data on a population of *Anartia amalthea*. On September 5th, for example, 27 adults were captured (left diagonal) and 27 adults were released (right diagonal): 19 of these were recaptured (and released again) on September 6th, 5 were recaptured on September 7th and 8th, 3 were recaptured on the 9th, etc. Dashes indicate no recaptures.

3. Capture per Unit Effort method (DeLury, 1947):

$$\frac{\text{No. captured at } t_0}{P_0} = \frac{\text{No. captured at } t_1}{P_1}$$

P_0

P_1

where P_0 = population size at time 0 and

P_1 = population size at time 1

Population sizes estimated by the above methods were remarkably close on all but two dates, and in agreement with the author's visual estimates of the flying population size. The population varied from 100 to 255 adults using the Modified Lincoln Index and from 78 to 276 adults using the Triple Catch Method (Table 1).

MODIFIED LINCOLN INDEX ESTIMATED POPULATION SIZE	DATE	TRIPLE CATCH METHOD ESTIMATED POPULATION SIZE	CAPTURE PER UNIT EFFORT	
			Percentage Captured	Estimated Population Size
108 adults	September 5	—	25 %	—
194 adults	September 6	78 adults	31 %	240 adults
161 adults	September 7	173 adults	21 %	107 adults
147 adults	September 8	148 adults	17 %	122 adults
255 adults	September 9	276 adults	12 %	176 adults
201 adults	September 10	96 adults	15 %	255 adults
100 adults	September 11	161 adults	22 %	147 adults

Table 1.—A summary of the capture-recapture data using three statistical methods: Modified Lincoln Index figures represent the population size on day one. Triple Catch Method figures represent the population size on day two. Capture per Unit Effort figures show the percentage of the estimated population captured each day and the estimated population size that day as determined from the Method's ratio procedure (see text). Modified Lincoln Index estimated population sizes were used to determine percentage of total population captured each day and for P_0 figures in Capture Per Unit effort calculations to determine P_1 on t_1 .

Number of Butterflies Recaptured	Number of Times Recaptured						
	0	1	2	3	4	5	6
	108	46	23	13	8	1	1

Table 2.—A summary of the frequencies of recapture for all 200 marked *Anartia amalthaea* butterflies. A total of 108 were never recaptured, 46 were recaptured once, 23 recaptured twice, etc.

The Capture per Unit Effort Method assumes that the percentage of the estimated population captured on each date will remain constant if the same unit of effort is exerted each date in sampling. Since this latter requirement was met by the design of the experimental procedure, we may calculate the population size at t_1 by using P_0 estimates determined by one of the other two methods. These figures (Table 1, last column) also show a relatively stable population in this small area of 30 x 35 meters. The Capture per Unit Effort ratios additionally give a good overall picture of the percentage of the total estimated population that was caught each day. Anywhere from 12 to 31% of the actual population present was captured, although within these extremes an average daily capture rate of 20% was normal.

Table 2 gives an overall view of the number of times butterflies were recaptured. The relatively high numbers of recaptures out of the total of 200 butterflies (129 females, 71 males) that were marked and released gives a good idea as to how many of the population are full-time residents. There were 92 out of 200 individuals that were marked and recaptured at least once in areas A, B, and C. Of the 92 recaptured at least once, 46 were recaptured at least once in the same area in which they were marked, 39 were recaptured at least once in another area other than the one in which they were originally marked, and 7 were recaptured at least once in two different areas other than the one in which they were originally marked. These data give a clear indication of the butterflies' restricted movement within a given subarea or only a portion of the whole area, since only 7 out of 92 butterflies moved throughout the 30 x 35 meter area during the eight-day study period.

A mortality curve is developed in Figure 8 by plotting the number of recaptures against the number of days of survival after marking. From this curve the survivorship rate is approximately 7 days. This figure could possibly be larger due to the fact that the study was only carried out for 8 days. A much longer study period would be necessary to determine the exact adult lifetime of *A. amalthea*.

A record was kept each day of the number of males and females captured. Figure 9 shows the daily fluctuation in the percent of females versus the percent of males present in the flying adult population. The sex ratio on a daily basis can also be read from this graph. The high percentage of males on September 8th could be due to the fact that it rained quite hard

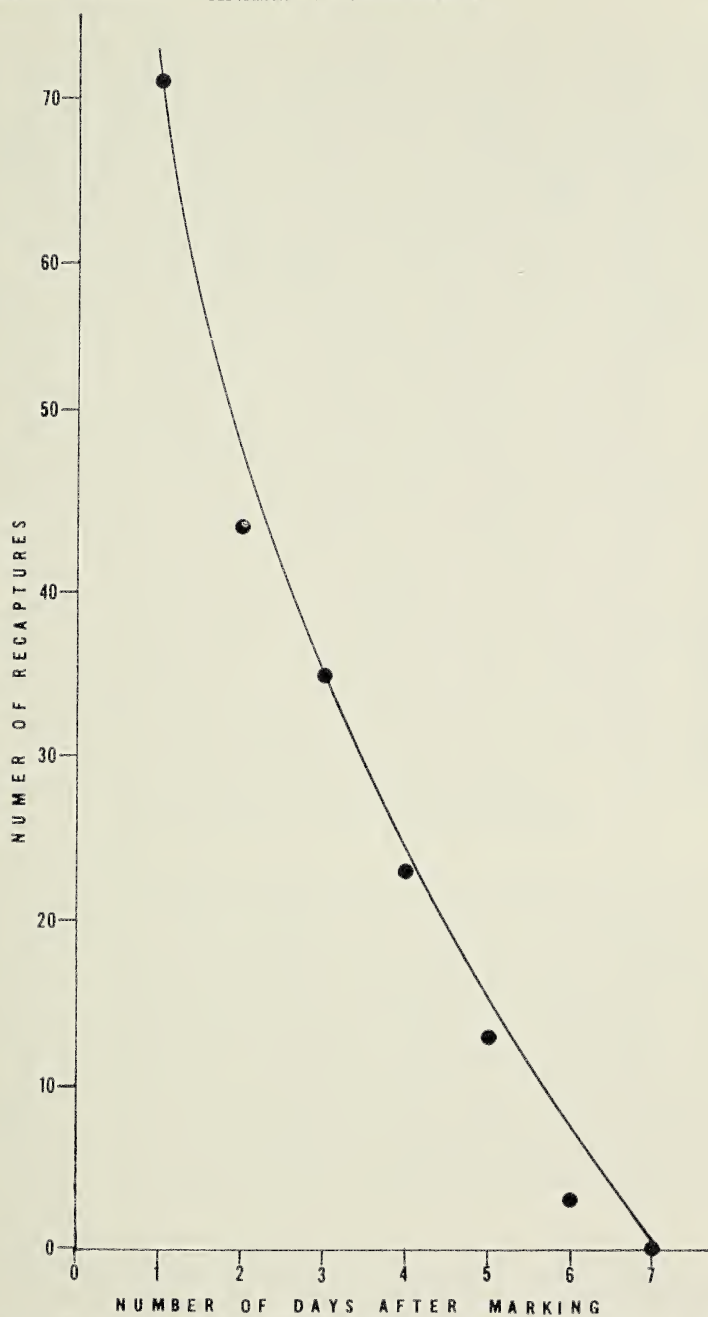


Fig. 8.—The number of recaptured specimens taken on successive days following initial marking. This graph can be read as a survivorship curve with the survivorship of the average adult being approximately 7 days.

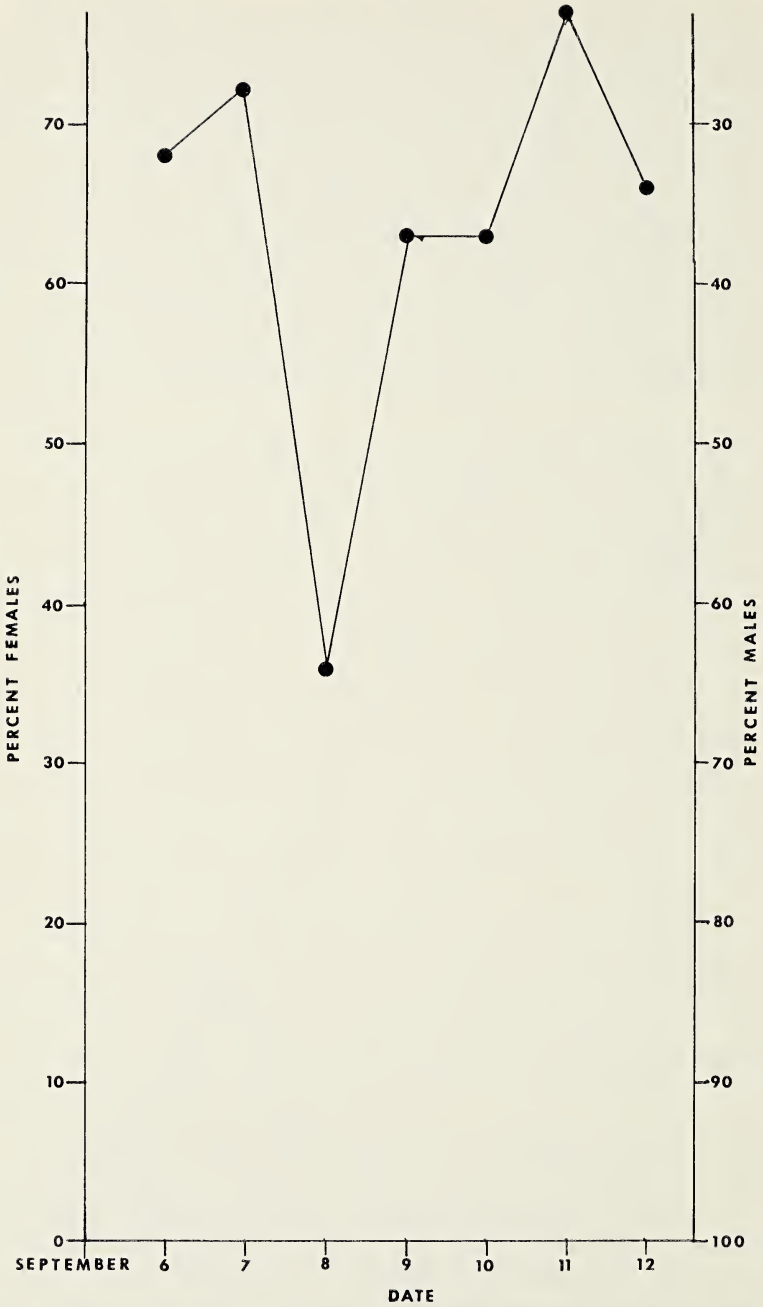


Fig. 9.—Representation of fluctuation in the percentage of females (left axis) and males (right axis) captured.

in the early morning of the eighth; many new males emerged that day after the rain, apparently ahead of a similar large female emergence following a day later. This may be similar to the strategy of various nearctic and other neotropical species of butterflies, where the males commonly emerge at least 24 hours ahead of most females and sperm maturation takes place during the waiting period (T. C. Emmel, personal communication). It would be interesting to know if similar male emergences regularly follow heavy rains. If so, the rains could provide a point of synchrony for male and female reproductive activities and hence increase breeding success. Such selective advantages to synchronize breeding have been hypothesized for tropical butterflies at the onset of the wet season in regions with a seasonal rainfall distribution (Emmel and Leck, 1970). Limoncocha lies in a region with a remarkably uniform distribution of rainfall throughout the year; hence occasional heavy rainstorms may serve the purpose of stimulating emergence in such areas for partly analogous selective reasons (of course, in seasonally wet areas the growth of larval foodplants is also stimulated by the rains and the adults emerge in abundance for this reason, also). Unfortunately for the testing of this hypothesis there were only light rains during the remaining days of this research at Limoncocha, none being as hard as the morning of the eighth. As can be seen from the graph, females were much more abundant than males on every day except the eighth.

DISCUSSION AND CONCLUSIONS

Population size:

The general population size is relatively stable. On very few occasions were there individuals flying out of or through the area observed. Consequently, one would conclude that the population studied is relatively isolated with few individuals entering or leaving the area. Females are predominant with males seemingly only predominant after a very hard rain. Since there is no so-called wet and dry seasons in this particular area, the period after a hard rain is the most opportune time for the emergence of new individuals. The males emerge in great numbers after rains, whereas the females seem to emerge at any time. This would insure a stable, constantly reproducing population.

Intrapopulation Movement

With half of the individuals recaptured at least once in another area other than the area in which they were originally marked, a certain degree of vagility, the ability to cross bar-

riers, is present in this particular species of butterfly. As can be seen from the map in Figure 5 there are natural barriers between areas A, B, and C except for one place along the road between area A and C. Few individuals were captured in this area due to the very low grass and the lack of flowers for feeding. From the data obtained it can clearly be seen that the entire study area should be called a single population of *Anartia amalthea* due to the extent of intrapopulation movement and potential gene exchange. Yet only 7 recaptured specimens actually were found to have moved through all three subareas during the eight-day period.

Social Interaction:

Courtship behavior was observed many times, but no actual mating was observed. Courtship begins with a female perched on a blade of grass or leaf with her wings fully spread. It has been determined that color is one attracting force in butterfly courtship (Crane, 1955). The female having her wings spread in this manner has all her dorsal color pattern exposed to the male. A male flying by the female will swoop in and flutter above the female. The moment the male begins to flutter several inches above the female, she closes her wings and will shift from side to side. This was determined to be a denial to the male. The male will continue fluttering for several seconds and then will fly away, once the female has started the side to side motion. From this it seems that motion is a contributing factor in courtship as described also in *Heliconius erato hydra* (Crane, 1955). No observation of successful courtship was observed.

The females that had their orange band experimentally colored red were observed so as to see the male reaction. These females would display their dorsal surface normally when perched on a blade of grass or leaf. Two cases of interaction between colored females with males were observed. The males would approach the females in the same manner as described previously with no alteration in their behavior. This would indicate that color is not the only determining factor that attracts males to females. The other major alternative factor in courtship behavior would be odor, which has also been determined to be an attracting power in the courtship behavior of certain other South American butterflies (Crane, 1955). These three basic factors which play an important role in courtship—motion, color, and odor—need to be experimentally manipulated in *Anartia amalthea* in a manner similar to that done by Emmel (1972) for the Central American species, *Anartia fatima*.

SUMMARY

Population size, intrapopulation movement, and social interaction were analyzed in a population of *Anartia amalthaea* (Nymphalidae: Nymphalinae) inhabiting a second-growth area at Limoncocha in the eastern Amazonian rain forest of Ecuador. A capture-mark-release-recapture study was carried out to determine population size. The estimated population size using three statistical methods ranged from 100 to 255 individuals in an area 30 by 35 meters during September 4-12, 1972. More females than males were present in the population except for one day following a hard rain, when a large emergence of males occurred.

Considerable movement of marked individuals occurred between different areas of the study plot, indicating a single large population of *Anartia amalthaea*. Almost half of the recaptures occurred in an area other than the area in which the butterflies were originally marked; however, only seven out of 92 recaptured individuals actually flew into all three subareas of the study site.

Social interaction observed between males and females suggested that odor, color, and motion are contributing factors in courtship behavior.

ACKNOWLEDGMENTS

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I thank Dr. Thomas C. Emmel, University of Florida, for his aid and critical review of this paper; Dr. James H. Enderson, The Colorado College, for his assistance; and Dr. Daniel B. Ward, Curator of the Herbarium, University of Florida, for his help in identifying plant specimens. I am also indebted to Miss Martha Hartzell for her invaluable technical assistance in the preparation of this manuscript.

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ON THE DISTRIBUTION OF SOME SKIPPERS IN ONTARIO

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MATHER'S PAPER (1963) and Shapiro's article (1970) on postglacial biogeography indicated the necessity for publishing certain data from recent Ontario skipper collections. Shapiro quotes Munroe (1969) as saying that both extensive surveys and intensive local studies are still revealing unexpected distributional information even in supposedly well worked areas. In Ontario, after a good lepidopterological start (Bethune, Saunders, Evens a.o.), a kind of stagnation occurred, especially between the two wars. This did not change much until recently when the Royal Ontario Museum and active members of the newly founded Toronto Entomologists' Association began again the survey of Ontario Lepidoptera. One result has been the discovery of many new locality and even species records, especially for Ontario skippers. Recent annotated systematic lists of Ontario Lepidoptera exist only for the butterflies and skippers of northern Ontario (Riotte 1971). When a list for southern Ontario will be completed is unknown and may still take many years. Meanwhile, the lack of published data is not encouraging.

In the following, therefore, the skipper species dealt with in Mather (1963) and Shapiro (1970) plus a few additions are listed with their known Ontario localities, as represented, for most records, in the collection of the Royal Ontario Museum.

Atalopedes campestris (Boisduval): 1 ♀ London, 21 SEP 1968
(Thorne)

Atrytone delaware Edwards: Grand Bend, Hamilton, Langton,
Milton, Wrigley Cors.

Atrytonopsis hianna Scudder: Ipperwash, Pinery Prov. Park

- Erynnis brizo* Boisduval: Halton Co. Forest, Kenworth, London, Pinery Prov. Park, St. Williams
- Erynnis martialis* Scudder: Bobcaygeon, Constance Bay, Dunnville, Grand Bend, Hamilton, Niagara Glen, Rondeau Prov. Park, St. Williams, Toronto
- Euphyes bimacula* Grote & Robinson: Brantford, Dundas, Marl L., Paris, S. Delaware, Sudbury, Toronto
- Euphyes conspicua* Edwards: Dorchester, Dunnville, Langton, Rondeau Prov. Park, St. Catharines
- Euphyes dion* Edwards: Brantford, Dundas, Dunn Twsp., Dunnville, Hamilton, Hyde Park Cors., Langton, London, Perth Road, Pt. Pelee, Rondeau Prov. Park, Toronto
- Euphyes dukesi* (Lindsey): 1 ♂ McGregor (Essex Co.), 11 JUL 1968 (Holmes)
- Poanes massasoit* Scudder: Bothwell, Dundalk, Rondeau Prov. Park
- Poanes viator* Edwards: Chaffeys Locks, Dundas, Galt, Hamilton, Hyde Park Cor., London, Milton, Perth Road, Rondeau Prov. Park, Toronto, Willowdale
- Polites origines* (Fabricius): Ayr, Bobcaygeon, Chaffeys Locks, Erindale, Go Home Bay, Grand Bend, Guelph, Milton, Ottawa, Primrose, Rondeau Prov. Park, Rouge Hill, Sarnia, St. Catharines, Toronto
- Pompeius verna* Edwards: Arkell, Cooksville, Dunnville, Milton, Morpeth, Pelee Isld., Rockway, Sarnia, Toronto
- Pyrgus communis* Grote: Pelee Isld., Pt. Pelee, St. Catharines
- Staphylus mazans hayhursti* Edwards: Pelee Isld., Pt. Pelee
- Thorybes bathyllus* J. E. Smith: Dunnville, Hamilton, London, New Glasgow, Simcoe, Toronto, Turkey Pt.

Especially to be noted are the recent new records (*campestris*, *dukesi*) from the north shore of L. Erie and the discovery of two previously recorded species (*dion*, *viator*) far to the east of earlier localities.

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OBSERVATIONS ON LIFE HISTORY OF *OARISMA POWESHEIK* (PARKER) 1870

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THE FOLLOWING NOTES, OBSERVATIONS AND LIFE HISTORY WORK on *Oarisma powesheik* was made during two seasons 1944-1945 and 1950-1951 at Lamberton Lake and Button Lake, which lies just east of Lamberton Lake, at Grand Rapids, Mich. I arrived at Lamberton Lake at about 2 P.M. on July 2, 1944 and collected there for balance of the day, making a careful search for *povesheik* all around the lake and along a creek which runs southerly from the lake, where I had found *povesheik* in previous years. I found one female specimen near the creek which was the only specimen observed. I saw two specimens of *C. muticum* at Lamberton Lake. Lamberton Lake has a marly bottom and the shore line is marshy and somewhat boggy, with shrubby cinquefoil growing in many places, accompanied with short marsh grasses and sedges. It is a typical marl bottom lake such as occurs in western Oakland Co. Small bog orchids and occasional yellow daisies and some ferns also occur on the boggy ground. Open hills occur to the west, and wooded areas to the east, surround the Lake at varying distances from the shore, leaving quite a marshy strip along the shore line.

The evening of July 2nd I stayed at a private home in Grand Rapids about two blocks west of road U.S. 131 and about two miles south of Lamberton Lake. On July 3rd, 1944, I explored Button Lake and found a fine colony of *povesheik* at N.W. corner and S.E. and E. side of the lake. The lake is similar to Lamberton Lake in general appearance, with similar marshy shore line. I found the butterfly quite plentiful here, the first specimens were found on flowers of white clover, that were in a lawn, which extended to the water's edge, in front of a

cottage. Just north of here along the lake and to an outlet stream which runs into Lamberton Lake I took eight or ten specimens, three on clover blossoms on a lawn and the balance in the short marshy grass area along the lake. I did not collect intensively but took sixteen more specimens along east shore of Button Lake.

Male specimens were attracted to flowers of yellow daisy. *O. powesheik* is usually hard to see on the wing, on account of its small size and swift flight. It flits its wings very rapidly and flies just above the grasses. One will see the white flash of its striped under surface of wings and must act very quickly in order to catch it. Sometimes, if not disturbed it will alight on the marsh grass or you will see it resting on the marsh grass and will have no trouble putting a net over it, but usually you will flush it up in walking through the grass and will have to act very quickly and have a very sharp eye to be able to follow it in flight and capture it. It is of course easy to catch if found on flowers of yellow daisy or on the shrubby cinquefoil. I caught two live females and put them in a bottle with some of the marsh grasses and took them home. One of the females was killed in the netting at top of the bottle but the other female laid sixteen eggs, three on the grasses and the balance on the sides and bottom of the milk bottle. These eggs were laid on July 4th and 5th, 1944. I found the female dead on the 6th and mounted it. All specimens taken at Grand Rapids at Button and Lamberton Lakes were practically in perfect condition, sixteen male and eight female. Twelve of the eggs hatched on July 13th and 14th and the other four on the sides of the bottle did not hatch. The caterpillars kept roaming around on the short marsh grasses, but would not eat. Four of them stationed themselves, head downward on a slight mat of silk near the tip of the blade of grass and remained stationary there until they died, refusing to eat. There were other small bog plants among the grasses brought home from Grand Rapids but the caterpillars refused to eat these. I obtained some tender lawn grass and put some of the caterpillars on this but most refused to eat. Three did however eat a little of the lawn grass. Finally two settled down each on a blade of lawn grass and started feeding regularly on it, eating along the edges of the blade. These two caterpillars, after starting to feed in earnest, remained each on a single blade of grass and did not move around, but stationed themselves on the underside of the blade, on the silken mat which they had made, with head usually

downward, but were quite sluggish and did not eat very much, usually only in early morning and late in the day. The caterpillar in its natural habitat evidently feeds on sedges or marsh grasses, although I did not get identifications of these.

EGG

One egg was laid near tip of blade of grass and another one on upper surface of blade of grass not far from tip. Size length 0.8 mm., width 0.7 mm., height about 0.5 mm. Color, pale yellowish green becoming darker and blotched with brownish just before hatching and showing outline of caterpillar within. It is mushroom shaped, with flattened bottom, smooth surface and being slightly depressed in micropyle. Eggs were laid July 5th, 1944 and hatched July 13 and 14, 1944, the length of egg stage being about nine days. Drawings were made of the egg, which appear in this paper.

First Caterpillar Instar or Caterpillar Stage

Length, 1.8 mm, when first hatched from egg July 13th and 14th, growing to about 4 mm. at end of instar on July 24th. Head large and prominent, in proportion to body, when first hatched, pale brown in color and in some cases with a darker brown stripe or patch (consisting of minute brown specks) on each side of face of head. Head smooth but very finely pitted or granulated. Head somewhat heart or wedge shaped, top being somewhat pointed, with slight depression at middle, face slightly depressed in middle of front. Body of caterpillar, legs and prolegs cream color, when first hatched becoming pale green as caterpillar feeds, with longitudinal light striping. No bristles on body except on last abdominal segment which has four minute colorless bristles at end of last segment. There are two colorless bristles on each side of head, one being just above mandibles. A drawing was made of this instar when first hatched, and also of the head, these drawings appearing in this paper. The length of this instar being about eleven days.

Second Caterpillar Instar

Both (the two remaining caterpillars) molted on the morning of July 24th for the first time. Length of caterpillar 4 mm. The cast off head dropped to the bottom, while the balance of molted skin remained fastened to the blade of grass, on the silken mat. The favored position of the caterpillar, while at rest, is near the end of the blade of grass, on upper surface, with head downward. It eats out chunks along the edges of the grass to the mid vein. The length of caterpillars at end of this instar which was Aug. 2nd, was about 7 mm. The length of this instar being about nine days.

Third Caterpillar Instar

Both caterpillars molted for the second time on Aug. 2nd, 1944. The caterpillars at end of second instar prepared a silken mat on either upper or lower side of blade of grass and fastened itself to it and remained there about two days before molting. It casts the head off first and pulls the rest of the caterpillar body out of the old skin leaving the cast off skin fastened to the blade of grass except the head which falls to the bottom. Caterpillars 6.5 mm. long just after molting for second time at beginning of third instar. Head and body grass green, body is striped longitudinally with very minute white or cream stripes, seven on each side of caterpillar, and one mid dorsally extending the full length of body. The lower white line, sub-stigmatal is the heaviest or broadest. The mid dorsal line is very fine, being hardly discernible, and slightly broken. On either side of this mid dorsal line is a dark green area, on the dorsal surface which is of a darker green, than on rest of the body. This darker green area is broadest at the center of the caterpillar and anteriorly and tapers to posterior end of the caterpillar where it runs out almost to a point.

The first longitudinal line or stripe from dorsal area is heavier than the fine mid dorsal line, the second line is fine and broken, the third line is heavier, the fourth line is fine, the fifth line is heavier, the sixth line is very fine and broken and the seventh or last line is substigmatal and is heavier than any of the other lines. The cast off molted skin was eaten by both of the remaining caterpillars shortly after the molt.

The caterpillar likes to wave its head back and forth when disturbed or when in search of food, although the caterpillar does not move around much but eats out gouges in the blade of grass to the mid rib. It rests much of the time on under surface of the blade of grass or surface of grass not exposed to direct light, about one third of way down from tip of blade. A favored stunt of the caterpillar, if transferred to new grass is to eat a small notch out of each side of the blade of grass, to the mid rib (the notches being close together and at about one half or one third of the length of the blade of grass from the tip). They then eat off end of the blade of grass, resting on underside of blade and between the cut notches and tip of blade. They are not heavy eaters and rest most of the time. They feed in early morning or near end of the day as a rule and rest with head downward toward base of stem of grass.

The head is lighter in color than rest of the body, and is a very pale green, inclined to clay color, with only a trace of brown color at apex of the head. There is a fringe of short, downwardly and outwardly curved colorless bristles on last abdominal segment. The spiracles are ringed with very faint brown, hardly discernible, except under high magnification. A drawing was made of the caterpillar at about end of third instar Aug. 18th and appears in this paper, length being 8.5 mm., width 0.8 to 0.9 mm. The actual length of caterpillars at end of this instar was 8.8 mm. and 9.3 mm.

Fourth Caterpillar Instar

The caterpillars in this instar are very similar in appearance and actions to those of the preceding instar.

Both caterpillars molted for the third time Aug. 18, 1944, length of one being 8.8 mm. and the other being 9.3 mm. at beginning of this instar. One caterpillar molted for fourth time at end of this instar, on September 12th, length being 11.5 mm., width 1 mm., height 0.8 mm., greatest height being at third abdominal segment. The other caterpillar molted on Sept. 16th, length about 10 mm. Length of fourth instar being about twenty-five days.

Fifth Caterpillar Instar

One caterpillar molted for the fourth time on September 12th, its length being 11.5 mm., width 1 mm., and height 0.8 mm., this date being the beginning of the fifth instar. Its greatest height was at the third or fourth abdominal segment. It is very similar in general appearance to the caterpillar in the preceding stage. The most conspicuous feature of the caterpillar is the dark green mid dorsal band, which tapers posteriorly almost to a point and extends into the head, where it flares out to the sides of the head, becoming horse shoe shaped in front of the head a little above the mandibles.

The dark green middorsal band is flanked on either side with a fine cream colored line, beyond which on each side of caterpillar are six other fine longitudinal cream colored lines. The lowest sub stigmatal line is broadest and more prominent. These fine lines on the sides of the caterpillar are very close together and give the caterpillar a yellowish green or cream color appearance in the sides, contrasting with the dark green mid-dorsal band. The upper side of head is lighter in color, as well as the horse shoe shaped figure in front, and an area just around the mandibles, while the interior center of head around horse shoe is darker green. The whole body of the

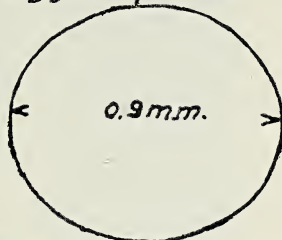
caterpillar and head is pale green or grass color in general appearance. The mandibles are brown, legs and pro-legs pale green, concolorous with body. The caterpillar is very sluggish in its movements and rests head downward and usually on underside of blade of grass. It spins a thin bed of silk, from the tip of blade to near its first notches cut out, to rest on when not feeding, and serve as a runway to go to end of blade of grass where it feeds. I presume this is done so that the caterpillar can cling more closely to the blade of grass in case of wind or storm. The caterpillar does not eat very much, and I have not observed it eating during the night. The two caterpillars became very sluggish the later part of September and remained in the same position, which was about midway down on the blade of grass and on under side, close to mid rib, with head downward. It made no preparation for winter and hibernated for the winter in this same position in this instar. It did not eat after the latter part of September and not until after hibernation. I kept the grass plant with the caterpillars on, in the house with windows open, until the first of November when I transferred the plant to a corrugated box about a foot square with cover on (not fitting tightly) and sides open, on our back porch, for the winter. We had a moderate Fall, and Winter weather began in early December. We had a very steady cold winter, with plenty of snow on the ground during December and January and until the middle of February, with continued low temperatures, a little above zero 8° to 12° for many days at a time during December and January, even with some sub-zero temperatures. There was no special protection provided for the hibernating caterpillars. The blades of grass became frozen, died and dropped down, but the caterpillars remained in the same position as before recorded. By the first of March the weather suddenly warmed up and we had a very mild March, the warmest I had ever experienced and along the later part of March, temperatures were close to 80° on several days, and grass was coming up in the lawns by the 24th, so I placed a fresh lawn grass plant in the box along side of the dried up plant the caterpillars were on, the caterpillars being still in the same position as previously recorded. We had some very warm days with temperatures close to 80° during the last ten days of March and I noticed on Mar. 29th that one caterpillar moved a little up on the dried blade of grass and ate a little of the dried blade of grass, so I pinned the two dried blades of grass, on which the caterpillars were, to the fresh lawn grass

Oarisma (Hesperia) powesheik (Parker 1870)

Egg, Side view

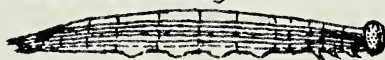


Egg, Top View

Caterpillar
First stage or instar

length at end of stage
4 mm.

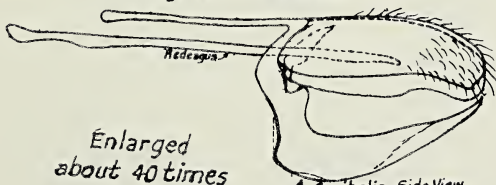
Face of head

Second caterpillar instar
at end of stage

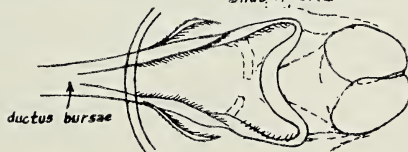
length 7.2 mm.
height 0.2 mm.

Third Caterpillar instar
at end of stage

length 8.5 mm.
width 0.8 mm to 0.9 mm.
height 0.2 mm.



Enlarged
about 40 times

♂ Genitalia, Side View
Slide No 277Q♀ Genitalia, Ventral View
Slide No 2100

plant, and placed them in my den in the house, leaving the windows open. On Mar. 30th I noticed that the one caterpillar that had moved just previously, ate a little off the tip of a fresh blade of grass. It rained most of the 31st and I sprinkled the grass and caterpillars with water. I noticed that the other caterpillar had eaten some of a blade of the fresh grass on the morning of April 1st and ate a little more about 12 P.M. on the same day. One of these caterpillars molted on April 12th for the fifth molt and measured 19 mm., while the other caterpillar molted on April 26 for the fifth molt and measured 16 mm. The length of this instar (the 5th) being from about end of September and through hibernation period to about middle or latter part of April.

Sixth Caterpillar Instar

As before stated, about April 1st the two caterpillars started feeding on the fresh blades of lawn grass and one molted on April 12th for the fifth molt and measured 19 mm., while the other caterpillar molted on April 26th for the fifth molt and measured 16 mm.

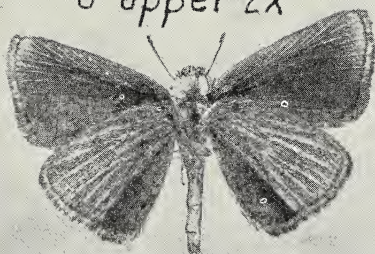
One of these caterpillars molted for the 6th time on May 14th and the other caterpillar died about May 26th. The caterpillar that died remained in one position on the blade of grass for ten days evidently in molting position. It seemed have been feeding well before the molting period and I cannot understand the cause of its death. However, it may have been injured by a few ants which I discovered on the fresh food plant, that I had brought in. I killed the ants as soon as I noticed them. They were rather large ants and may have injured the caterpillar although there was no apparent injury. The length of this instar, the sixth, is either 32 days or 18 days, probably the latter, as my record is incomplete here. The length of the 6th instar then is evidently from about the middle or latter part of April to about the middle of May. The caterpillars in this instar looked very similar to those of the preceding instar.

Seventh Caterpillar Instar or Stage

The one remaining caterpillar that molted on May 14th for the sixth molt has eaten more during this stage than in any of the preceding stages. It seemed to prefer the slender blades of grass near the base of the plant and eats most during the later part of the day. It will eat out a notch in the blade of grass to the mid rib, on each side of the blade of grass, about two thirds or one half way up from the base of the blade, and then crawl out to the end of the blade of grass and eat the blade

Oarisma powesheik

♂ upper 2x



♂ lower 2x



♀ upper 2x



♀ lower 2x

Fifth instar
lateral viewFifth instar
dorsal view

Chrysalis

of grass complete from the end downward, almost to where it first ate out the notches. The caterpillar sometimes moves around in a restless manner, maybe in search of better food or just before the molting period. It may even leave its food plant and crawl on the sides of the breeding cage and if left there would probably take up its position for molting. During these restless periods it will crawl out to the end of a blade of grass and extend its head and thoracic segments beyond the tip of the blade and wave its head and thoracic segments beyond the tip of the blade of grass and wave its head and that portion of its body back and forth, and if its head gets in touch of another blade or the side of the breeding cage the caterpillar will usually take hold of this object and pull the rest of its body to it.

At the beginning of this stage at end of sixth molt May 14th, the length of caterpillar was about 19mm. On May 30th the length of the caterpillar was 23.6 mm., greatest height 3 mm. at 2nd abdominal segment, width 2.8 mm. at 1st abdominal segment. May 30th may have been close to end of seventh instar but my records from seventh instar to imago have been either lost or misplaced. But judging from complete life histories of other small butterflies (such as *Calephelis muticum*, which I have made) *O. powesheik* should have one or two more caterpillar instars after the seventh instar, in addition to the chrysalis stage, before imago, so there is probably eight or nine caterpillar instars for *O. powesheik*. I have in my collection 35 *Orisma powesheik*, 13 taken on July 3, 7 on July 5th, 10 on July 9th, 1 on July 13, 2 on July 18, 1937, all being collected at Grand Rapids at Lamberton and Button Lakes in 1930, 1937, 1938, 1939, 1944, 1948 and 1950.

All of these specimens except two, taken by Dr. W. W. Necomb in 1930, were collected by myself. All but about six of these were males, it being difficult to determine sex by superficial examination. However, the genitalia of both male and female are very distinctive and drawings were made of them which accompany this article.

Recently *O. powesheik* has been taken in other localities in Michigan, in Livingston and Oakland Co.s and other places by M. C. Nielsen and R. W. Holzman. Mr. Holzman is making a special effort to study this butterfly and determine its distribution in Michigan. *Oarisma powesheik* was described by Parker in 1870 under *Hesperia powesheik* in Am. Ent. II 271, 1870. In Dyars list, 1902, it is listed Iowa, Ill. to Utah. I have one

specimen from Lake Okoboji, Iowa, June 26, 1927. U.S.N.M. Slide 2769. I have one specimen from Paradise Park, White Mts., Apache Co., Ariz., July 15, 1936. Chermock Coll. Slide No. 2772. I have one specimen from Riding Mts., Manitoba, June 6, 1934, Chermock Coll. which Chermock calls a new species but it is evidently *O. powesheik*, Slide No. 2771.

Oarisma powesheik is a small skipper butterfly (Hesperiidae Family) about an inch in expanse of wings. The ground color of entire upper wing surface is of a rather dark brown color with a narrow patch of light yellowish along the inner two thirds of costa, and with a few longitudinal very faint streaks of yellowish on the balance of fore and hind wings.

On the lower wing surface the ground color is also a rather dark brown color which is particularly evident on the primary wings and by a patch at the inner angle of the secondaries. On the lower wing surface there is faint yellowish coloring along the costa and outer part of the primaries. The lower surface of the secondaries is most conspicuous, with the veins on the upper and outer two thirds white and with the dark patch at the inner angle of the secondaries. The dorsal surface of abdomen, thorax, head and antenna is dark brown, streaked with faint yellowish, while the ventral surface of same is white.

Oarisma powesheik may be confused with *Thymelicus lineola*, a European species introduced into Michigan about 1930, but the latter is quite different having both upper and lower wing surfaces, almost entirely a light yellowish brown color, with edge of wings and veins black.

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HABITAT: *Oeneis jutta ascerta* Masters & Sorensen

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Oeneis jutta ascerta inhabits acid sphagnum-moss bogs from southeast Manitoba eastward to Maine. The photograph was taken in the type locality, Solana State Forest, Aitkin County, Minnesota. Bogs such as this one, containing moderate growths of Black Spruce (*Picea mariana* Mill.), are preferred over those with heavy or sparse growths. Males establish "territories" in open lanes among the spruce and will return time and time again to a favored perch.

The larval foodplant, Cottongrass (*Eriophorum spissum* Fern.—which is a sedge and not a grass), can be seen in the foreground; its cottony perianth bristles appearing like small white flowers. Other plants that are always found in these bogs include Labrador Tea (*Ledum groenlandicum* L.), Leather-leaf (*Chamaedaphne calyculata* L.), Sphagnum Moss (*Sphagnum* species), and Feather Moss (*Pleurozium* species).

Oeneis jutta has a biennial life-cycle which produces adults once every two years. At this locality adult examples are found only in odd-numbered years.



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DISPERSAL IN A COSMOPOLITAN BUTTERFLY SPECIES (*PIERIS RAPAE*) HAVING OPEN POPULATION STRUCTURE

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THE DISPERSAL BEHAVIOR OF A species is one of the instrumental factors determining the degree of isolation of neighboring populations or subpopulations over an extended area. Species with a low rate of dispersal due to lack of vagility, intrinsic barriers to dispersal, or extrinsic barriers, should tend to have closed population structures promoting a high degree of inbreeding. On the other hand, cosmopolitan butterflies might be frequently expected to show high dispersal capabilities with a corresponding open population structure permitting relatively panmictic gene flow. The present short study tested this concept by assessing dispersal behavior in the common cabbage white butterfly, *Pieris rapae* Linnaeus (Pieridae), at a montane locality in southwestern Virginia.

All field work was done in the Rocky Sink canyon area, 2400 feet elevation, on the southeast side of Johns Creek Mountain (between Newport and Pembroke, northwest of Highway 460), Giles County, Virginia, from July 17 to 21, 1970. Two areas (CENTRAL and LOWER) were established in the main canyon, separated by about 400 meters of suitable habitat, and a third area (UPPER) was delimited in an adjacent side canyon. The UPPER area was separated from the CENTRAL area by a minimum of 250 meters, much of which was forested. Mountain slopes bordered all areas (see Figure 1). Each of the three areas was worked simultaneously by separate teams of four collectors, for 75 minutes during the peak of flight activity (1015-1130 hours EDT). New captures were marked with Magic Marker pens on the underside of the wings in a 1-2-4-7 code system (Ehrlich and Davidson, 1960), using small blue, red, and green dots for the specimens from each area. Releases were made at the end of the marking period each day. Recaptures were recorded by number, sex, and location so as to facilitate evaluation of dispersal rates.

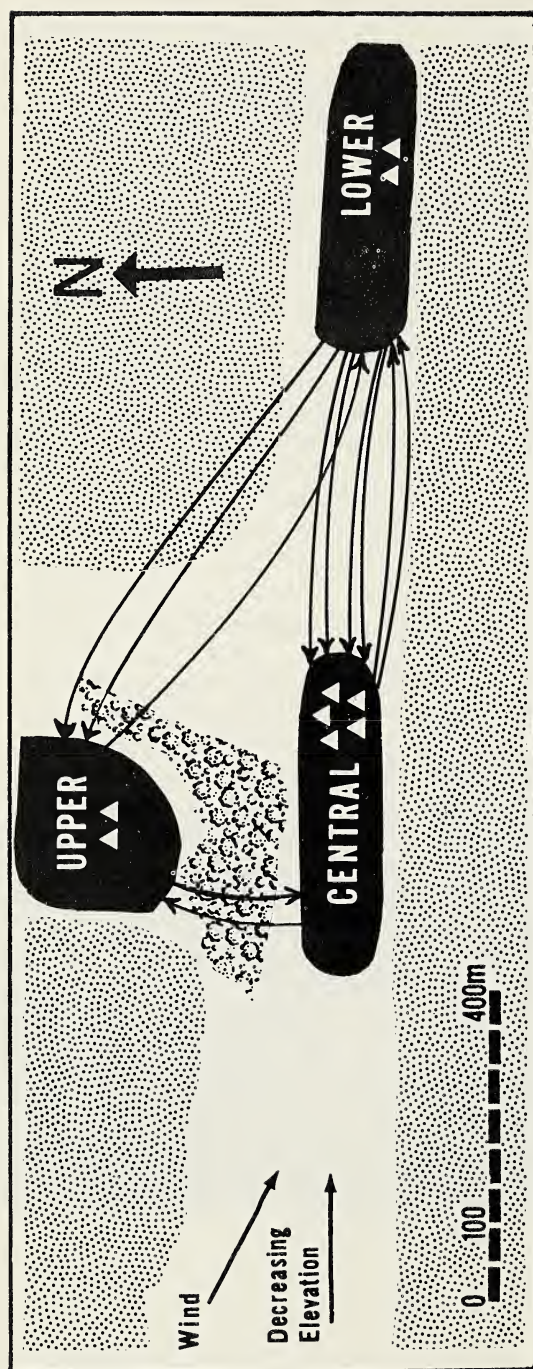


Fig. 1.—Map of three areas used for mark-recapture experiments on *Pieris rapae*: Rocky Sink area, 2400', at junction of unimproved roads 605 and 602, SE side of Johns Creek Mountain, Giles Co., Virginia. U.S. Highway 460 is located about one mile to the south of this study area. The shaded areas represent mountain slopes. A small brook, with bordering wet meadows, flows from left to right in the figure through the main canyon. Arrows between marking areas show known movements of marked individuals as determined by capture and recapture sites. White triangles indicate recaptured specimens that had not moved.

Table 1. Capture-recapture results with Pieris rapae
at Rocky Sink in Giles County, Virginia, 17-21 July 1970.

Area		Day 1 7/17	Day 2 7/18	Day 3 7/21	Total		Comments on Recaptures (see Fig. 1)
					Butterflies (Sex ratio)		
UPPER	New Captures	28	49	36	86 ♂♂ 27 ♀♀		2 ♂♂ stationary 3 ♂♂ known to move in 1 ♂, 1 ♀ known to move out
	Recaptures	--	2	3	(3.19♂: 1.00♀)		
CENTRAL	New Captures	20	24	17	27 ♂♂ 34 ♀♀		2 ♂♂, 3 ♀♀ stationary 3 ♂♂, 2 ♀♀ known to move out 2 ♂♂, 3 ♀♀ known to move in
	Recaptures	--	5	5	(0.79♂: 1.00♀)		
LOWER	New Captures	11	20	31	33 ♂♂ 29 ♀♀		1 ♂, 1 ♀ stationary 2 ♂, 1 ♀ known to move out 2 ♂♂, 1 ♀ known to move in
	Recaptures	--	3	2	(1.14♂: 1.00♀)		

The results are given in Table 1 and the movements of recaptured marked specimens are shown in Figure 1. It is clear that both sexes disperse at the same frequency (per cent of marked population) and that males and females move the same relative distances and compass directions, within the limits of this capture-recapture program. Wind direction and slope may influence movement in that more butterflies moved against the wind and up the slope than down-wind and down-slope. Females occur in highest frequency in the "CENTRAL" area, adjacent to the small stream where oviposition sites are abundant as compared to the drier slopes.

The three delimited areas, despite their separation by physical distance, are not true populations. Instead, the dispersal behavior exhibited by *Pieris rapae* in these experiments and from other observations indicates that a population unit would be very large, diffuse, and hard to define. Panmixis is unquestionably promoted in single-egg-laying species with this type of open population structure. Anecdotal information is available which indicates the presence of this type of population structure in butterflies of several families (e.g., Brower, 1961; Emmel and Emmel, 1962: p. 41-42; Emmel, 1964) and it has recently been analyzed in detail (Brussard and Ehrlich, 1970) for the satyrid butterfly *Erebia epipsodea*.

ACKNOWLEDGMENTS

This research was done with the aid of the students in my summer 1970 Ecological Genetics course at the University of Virginia Mountain Lake Biological Station. I am also grateful to J. J. Murray, station director, for his support and interest in the research done in this course.

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MATING OF BUTTERFLIES

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THE PURPOSE OF THIS PAPER is to present the results of my studies of mating of eleven species and to review previous work on mating. All aspects of mating are included, including courtship, change of mating behavior with age, the roles of vision and odor during courtship, female behavior to reject courting males, anatomical source of pheromones, prezygotic isolating mechanisms, copulating posture, behavior during copulation, duration of copulation, number of matings per male and per female, the fate of sperm from different matings of one female, and the adaptive significance of a sphragis and of multiple mating. A detailed review of wing and body movements during courtship, too lengthy for this report, will be published later. The seven species I studied are: *Parnassius phoebus*, *Euchloe ausonides*, *Neominois ridingsi*, *Poladryas minuta*, *Precis coenia*, *Lycaena arota*, *L. xanthoides*, *Hypaurotis crysalus*, *Ochlodes snowi*, *Hesperia pahaska*, and *Amblyscirtes simius*. Details on these species will appear elsewhere. Perching behavior is defined as a mate-locating method in which males sit at characteristic sites and dart out at passing objects in search of females. Patrolling is a mate-locating method in which males fly almost constantly in search of females.

ACKNOWLEDGMENTS

I thank Jerry A. Powell, Glenn R. Scott, and A. Shapiro for criticizing the manuscript.

Courtship (as distinct from copulation)

There is a tremendous diversity of courtship behavior. In patrolling species, the two sexes may meet during flight or the flying male may meet a female at rest. In perching species, the female flies near the male, who then pursues. Subsequent events can then be divided into aerial events and ground events although in some species identical activities may occur in the air and on the ground or plant. In the aerial phase, which is omitted altogether in some species and in courtships involving highly receptive females in other species, the two sexes often merely flutter about each other, or fly in stereotyped patterns, or one or both sexes may perform specialized acts for transferring pheromones. The aerial flight usually results in the female alighting, whereupon the receptive female usually becomes inactive until copulation occurs; successful matings with newly killed females have been obtained experimentally in *Euphydryas editha* and *Anthocaris charltonia* (Labine, 1966), *Hypolimnys misippus* (Stride, 1956), and *Argynnis paphia* (Magnus, 1950). Unreceptive females of some species may flap the wings or fly a special pattern (rejection dances), or may adopt a special rejection posture. After the female alights, the male may continue to fly about the female, or may land, whereupon one or both sexes may still flutter their wings, and the male may perform complicated maneuvers with his wings, antennae, or legs, etc. Copulation may then occur, or various courtship events may then be repeated. Courtships in different species may range from very simple with few events (*Parnassius*) to very complex (*Hipparchia semele*, Tinbergen et al. 1942; *Argynnis paphia*, Magnus, 1950). Little variation of the behavioral sequence occurs in successful courtship of some taxa (*Danaus*, Brower et al. 1965), but courtship may be quite variable in other taxa because various behaviors may be completely omitted, depending on the receptivity or age of the female (*Heliconius*, Crane, 1957; *Precis*; *Amblyscirtes*). Closely related species usually have similar courtship movements.

Courtship serves two functions: to promote mating between individuals of the same species and to prevent mating with other species. Because of the second function and the necessity of distinguishing mates from predators, individuals should be unreceptive toward the majority of animals in their habitat, and visual or olfactory characteristics that allow mutual recognition of the sexes will be selected for, even though these characteristics may have no other function. Courtship is probably a major

isolating mechanism in butterflies but isolating mechanisms have been poorly studied (see below). Most of the events during courtship have no useful function other than as token stimuli. In a few cases, however, behaviors seem to have some obvious function. The hairpencilling of *Danaus* (Brower et al. 1965), upward flight of *Argynnis* (Magnus, 1950), and bowing of *Hipparchia semele* (Tinbergen et al. 1942), all serve to place the male scent organs next to the female antennae, and wing fluttering of males of many other species serves the same function. Likewise, exposure of female hairpencils in *Heliconius* (Crane, 1957), and female glands in *Gonepteryx* (Lederer, 1938a), etc., serves the same function. Dropping of male *Danaus* onto some females makes them fly so that courtship can be repeated, usually with more success. "Male nudging" (male creeping under the wings next to the abdomen of the female, in various Nymphalidae) seems partly to make the female assume the copulatory position.

Sexual selection is important in butterflies, at least on males. Unreceptive females can sometimes be made to copulate after prolonged courtship by the male (*Ascia monuste*, Nielsen, 1961; *Aporia crataegi*, Stellwaag, 1924; *Pieris protodice*, Abbott, 1959; *Gonepteryx rhamni*, Lederer, 1938a; *Danaus gilippus*, Brower et al. 1965; *Precis coenia*, *Amblyscirtes*), which suggests that there is strong selection for males with persistent courtship or other behavioral, visual or olfactory attributes that increase female receptivity. Female butterflies almost never fly toward males to mate (except if she remains unmated for many days, see below), so that the only types of contacts in which copulation results are between receptive males and receptive or mildly unreceptive females. This places selective pressure on the male to develop sexual characteristics to make the unreceptive females receptive, because females do not have to make unreceptive males receptive. This may explain why males have brighter colors, in addition to their more active role in courtship. Also, sexual selection is stronger on the male because there is greater variance in number of matings per male than in number of matings per female and because females generally live longer (see below). The only selective pressures on the female are to inform the male of the specific identity of the female, and the various rejection behaviors described below are also of value to both sexes as they repulse a male which would otherwise harass the female for some time. Rejection dances

TABLE 1. Minimum age of mating.

Males

*Can mate on the first day of adult life**Poladryas minuta arachne*; Scott, this study*Phalanta phalanta*; Phipps, 1968*Chlosyne lacinia*; Drummond et al., 1970*Pieris brassicae* (mates most frequently the fifth day); David & Gardiner, 1961*Must mature several days before mating**Precis coenia* must mature at least a day before mating; Scott, this study*Euphydryas editha* must mature a day; Drummond et al., 1970*Cercyonis* spp. must mature a day, Drummond et al., 1970*Anthocharis* spp. take 1-2 days before mating; Lederer, 1941*Colias* spp. take 1-4 days before mating; Lederer, 1941*Hypolimnys misippus* do not court readily until the third day; Stride, 1956*Argynnis paphia* males start to patrol about the 2nd or 3rd day, so do not mate until then; Magnus, 1950*Heliconius erato* do not mate until the 3rd to 5th day; Crane, 1955*Limenitis* spp. do not mate until the 5th day; Platt, 1969

Females

*Can mate on the first day**Parnassius phoebus*; Scott, this study*Papilio rutulus*; Scott, this study*Anthocharis* spp.; Lederer, 1941*Pieris protodice*; Shapiro, 1970*Pieris rapae* (mate most readily the second day); Shapiro, 1970*Pieris brassicae* (mate most readily on fifth day); David & Gardiner, 1961*Eurema nicippe*; O. Shields & Emmel, 1973*Colias eurytheme*; Stern & Smith, 1960*Colias* spp.; Lederer, 1941*Ascia monuste*; Nielsen, 1961*Acraea* spp.; Marshall, 1901*Cercyonis* spp.; Drummond et al., 1970*Heliconius erato*; L. Gilbert, photograph*Heliconius charitonius*; Edwards, 1881*Phalanta phalanta*; Phipps, 1968*Hypolimnys misippus*; Stride, 1956*Anartia fatima*; Emmel, 1972*Limenitis* spp. (females mate most readily a day or two after emergence, but can mate after more than two weeks); Platt, 1969*Oeneis jutta*; Masters & Sorensen, 1969*Euphydryas editha*; Labine, 1966*Poladryas minuta*; Scott, this study*Must mature 1-2 days before mating**Chlosyne lacinia*; Drummond et al., 1970

may be subject to both individual selection on females and group selection on populations, because courtship of a highly unreceptive female wastes the male's time also.

Change of mating behavior with age

1) *Minimum age of mating* (Table 1) is earlier in females than in males. Females can mate the first day of adult life in almost all species, although females may mate more readily after a day or two. In contrast, males usually mate only after several days. Males often develop distinctive odors (male pheromones) only after a few days (Clark, 1926; *Papilio zelicaon*, Shields, 1967). Females of perching species often must fly to the mating sites, so may be older than patrolling species at first mating. The difference between the sexes in minimum age of mating is due to three reasons. Males almost always take the active role in mate-finding, so must be capable of stronger flight so must wait a few days before actively perching or patrolling. Second, it is advantageous to fertilize the females as soon as possible in the usual precopulation period so that the time for oviposition is not reduced. Finally, males almost always emerge a few days before females. In laboratory emergence, males emerge a day earlier in *Precis coenia*, one to two days earlier in *Pieris brassicae* (Roer, 1959), *Boloria toddi* and *Phyciodes tharos* (Oliver, 1972), and *Colias eurytheme* (Stern and Smith, 1960), and there are dozens of literature references to males predominating in the early part of the flight period and females more abundant later. Early emergence of males has no significance in continuously emerging species.

2) *Change of courtship with age*. In males, courtship behavior stays the same with age, but in females the behavior may change. Females on the first day may remain motionless, and the male may then join with few preliminaries, whereas older females may take a more active role. This is probably true in the patrolling species in which matings occur before the female's wings are expanded (see below), and in others. In *Heliconius*, one day old females eliminate all movements, and elicit almost no precopulatory behavior from males probably because of the greater strength of the pheromone when young (it is very strong in the pupa). Full courtship occurs only on the second or third days, and older females show progressively fewer responses. In *Colias*, wing movements of newly emerged females are limited in comparison with those of older females. In several species older mated females that are not seeking

mates fly after other individuals of both sexes, becoming more "masculine" in behavior (*Pieris rapae*, Priddle, 1960; *Heliconius*, Crane, 1955).

If a female remains unmated for many days, she flies toward passing males to seek a mate (*Parnassius phoebus*; *Heliconius*, Crane, 1955; *Hypolimnas*, Stride, 1956; *Danaus chrysippus*, Stride, 1958b), a behavior not shown by younger virgin females. In the perching species in which females fly to the mating sites after emergence, they merely fly about the mating site but do not approach males like the above species.

Role of vision in courtship. Experiments with models show that movement, size, and general color are important in courtship. Super-optimal models that flutter faster or are larger or have brighter colors than normal can be constructed in at least some species. The meeting of male and female involves the initial approach, and then the pursuing response of the male. In perching species (designated hereafter by the letter "P"), the initial approach is based principally on the movement and size of the female, while color and pheromones are more important later. In many patrolling species (designated hereafter by the letter "A") males often find sitting females, so that movement is probably less used, while color and pheromones are important both for the initial approach and later. This suggests that females of patrolling species should have brighter or more distinctive colors than females of perching species; this trend may be shown in the future when more species have been behaviorally classified. Most of the previous work has involved characteristics of the female. More work is needed on the use of male characteristics in courtship; many male butterflies are more colorful than the female, suggesting that male color may be more important in courtship than female color (or it may help males to recognize each other?). On the other hand, since the male is usually behind the female during courtship, male color would seem less important. Many polymorphisms in butterflies are limited to females, especially those involved in mimicry; perhaps sexual selection is paramount in males and selection to minimize predation more important in females.

Fluttering of the female is important for the approach of male *Hipparchia semele* (P, Tinbergen et al. 1942), *Argynnis paphia* (A, Magnus, 1954), *Limenitis camilla* (P, Lederer, 1960), and *Poladryas*, and probably many others, except that in most patrolling species males can approach and court resting females.

In perching *Poladryas*, tethered females do not attract males unless they flutter. In *A. paphia* models were more attractive to males the more rapidly they were fluttered, up to the flicker fusion frequency of the male eye. In *Heliconius*, male fluttering contributes to courtship success visually as well as olfactorily by disseminating androconial scales.

In *Hipparchia semele*, *Argynnis paphia*, and *Papilio rutulus* (A, Brower 1959), size of the female model is important for the initial approach in that models larger than the normal female produce more male responses (are supernormal). In *Hypolimnna misippus* (P, Stride, 1957), size is not important if the female model is not too large or too small. In *Precis* (P) and *Amblyscirtes* (P), males sometimes mate with crippled females whose wings are not normal size, and in many patrolling species males can mate with females whose wings are not yet expanded, so that the presence of superoptimal size either is not general or is not very important.

Shape of the female model was shown not to be important in *H. semele* (Tinbergen et al. 1942) and *A. paphia* (Magnus, 1954), and was of little importance in *Hypolimnna* (Stride, 1956), in which models with four wings were more attractive than those with two (which could be due to size rather than shape.)

The normal color of the female has been shown to be more attractive than other colors in many species: *Pieris napi* (A, Petersen et al. 1952), *P. rapae* (A, Obara, 1970), *A. paphia* (A), *Papilio glaucus*-group (A, Brower, 1959), *Boloria euphrosyne* (A, Eltringham, 1919), *Hypolimnna*, *Hypaurotis crysalus* (A), *Liminitis camilla*, *Anthocaris sara* (A, Evans, 1952), *Poladryas* (P), *Precis*, *Parnassius* (A), *Neophasia terlooiti* (A, J. W. MacSwain, oral communication), *Morpho* (A), *Anartia fatima* (A, Emmel, 1972). In *Heliconius erato*, pure red models of the female were more attractive than the normal female which has a red patch on black wings (Crane, 1955). In *Hipparchia semele* all colors gave about the same approach response, except that black was slightly superoptimal and white drew only 63% as many responses as brown (Tinbergen et al. 1942). If the pursuing response had also been studied, the acceptable color range might have been narrowed. Many butterflies are dull brown like *Hipparchia*, and in these color may not be as important as in other species. Swihart (1967b) showed for six species that the neural mechanism selects the output from optical receptors to maximize stimulation by the normal wing color. The male

may use the female colors more if receptive females spread their wings in courtship, as does *Hypolimnias*. The black color of male *Hypolimnias* is important for recognition by the female, but the white patches serve only to deter other males (Stride, 1958b). Male *Precis* artificially colored black courted females normally, even though blackened females were not courted normally, suggesting that movement of the male is more important than color, since the male is behind the female and the female never views his upperside directly. White inhibits the courtship responses of many dark colored butterflies (Stride, 1958a).

When the wings are multicolored, the gross but not detailed pattern may be used in courtship. In *Limenitis camilla*, which has a broad white stripe on dark wings, models with the normal width, spacing, and pattern of the white bands are more attractive to the male than other models (Lederer, 1960). In *Hypolimnias*, the color of the female hindwings is more important in eliciting male response than frontwing color (Stride, 1956), and the black border of the female wings increases male response slightly (Stride, 1957). In *Anartia fatima*, the white band is most attractive to males but red spots slightly increase attractiveness (Emmel, 1972). The detailed pattern of lines and spots of the female is not used by males in the following species: the black spots of *Pieris rapae* (Obara, 1970); the dark lines of *Pieris napi* (Petersen et al. 1952); the dark veins and spots of *Argynnis paphia* (Magnus, 1958), the orange spots and black areas of *Hypaurotis*; and the individual eyespots of *Precis*.

Female behavior to reject males. Females of many species have special rejection behavior which visually causes the male to leave or to cease courtship for a moment. The following 8 behaviors have been observed. Numbers 1 and 2 can be called "rejection dances," and numbers 3 to 5 "rejection postures."

1) The female flies vertically until the male returns to the ground in *Poladryas* (unreceptive virgins may also flutter slightly), *Colias*, *Gonepteryx rhamni* (Lederer, 1938a), *Pieris rapae* (in all three the pierid rejection posture may also be used, or the female flies away), *Erynnis tristis* (Shields, 1967), *Hypolimnias* (mated females only, Stride, 1958b).

2) The female rapidly flaps her wings in *Hipparchia* (Tinbergen et al., 1942), *Chlosyne gorgone* and *C. nycteis*, *Precis coenia*, *Lycaena* spp., *Hesperia* spp., *Ochlodes snowi*, *Poladryas* (unreceptive virgins flutter slightly), *Euphydryas editha* (La-

bine, 1966), and *Hypolimnias* (mated females "quiver" like the male and fly upward).

3) The Pieridae rejection posture (abdomen vertical, wings horizontal) has been recorded in the following Pieridae and probably occurs in all: *Colias*, *Anthocaris* (Lederer, 1941; Temple, 1953), *Euchloe ausonides*, *Pieris rapae*, *Pieris brassicae* (David and Gardiner, 1961), *P. protodice* (Shapiro, 1970), *Aporia crataegi* (Stellwaag, 1924), *Gonepteryx rhamni*, and *Glutaphrissa saba* (the last two may have a repellent pheromone, See No. 8 below). *Heliconius erato* uses this posture to reject males, while other *Heliconius* spp. use the posture to attract males (Lawrence Gilbert, oral communication).

4) The unreceptive female spreads her wings in *Graphium podalirius* (Lederer, 1960).

5) Unreceptive virgin female *Hypolimnias* close the wings above the thorax when the male courts (the wings are spread during successful courtship), and the female flies away or drops to the ground if the male tries to copulate. Mated unreceptive female *Hypolimnias* also quiver like the male and fly upward; this species has the most complicated rejection behavior known in butterflies (Stride, 1958b).

6) Unreceptive females have no special rejection behavior and merely fly away in *Danaus gilippus* (Brower et al. 1965). *Nordmannia ilicis* (Fiori, 1957), *Neominois*, *Amblyscirtes*, *Hypaurotis* (or crawls away), *Parnassius*, *Limenitis camilla* (Lederer, 1960), *Papilio dardanus*, and *P. demodocus* (both Stride, 1958b). In *Parnassius* and *Limenitis* the female may close her wings when a male comes near as in number 5, but this seems to be to prevent recognition by the male. In species with special rejection behaviors the female may also merely fly away (*Colias*, *Pieris rapae*, *Hypolimnias*). *P. rapae* females may drop to the ground, and then do the Pieridae rejection posture.

7) Males do not follow mated older females apparently because of lack of pheromone production in *Agathymus* (Roever, 1964), *Parnassius*, and to some extent in *Euphydryas editha* (Labine, 1966) and *Precis*. Males turn away from mated *Argynnis paphia* after antennal contact (Magnus, 1963).

8) The female may have a repellent pheromone in *Gonepteryx rhamni* (Lederer, 1938a) and *Glutaphrissa saba* (Poulton, 1912) since both extrude the abdominal glands during the rejection posture and at least *Gonepteryx* does not extrude them during normal successful courtship. *Pieris* and *Euchloe* have complicated lobes on the end of the abdomen, which perhaps

emit a pheromone. In *Heliconius* females develop a strong odor an hour after mating which prevents further matings and which is apparently deposited by the male (Lawrence Gilbert, oral communication). A different pheromone is used before and during courtship (Crane, 1955). Males of *Heliconius erato* sitting on a female pupa, waiting for the virgin to emerge fly away when a mated female is brought near (Lawrence Gilbert, oral communication).

There is no apparent taxonomic correlation in the above rejection behaviors, except for the Pierid rejection posture. Most of the rejection behaviors above are not shown by the male, but in some cases the female rejection behavior mimics some behavior of males and so perhaps visually convinces the male he is courting another male: In *Poladryas*, *Erynnis*, and occasionally in *Colias*, the female flies up in the air which mimics the vertical encounters of two males. In *Precis*, females flutter, which imitates male courtship fluttering. In *Hypolimnias*, females may quiver like courting males, and females fly up in the air, which mimics vertical encounters which probably occur because it is a perching species. Males can sometimes overcome rejection behavior after prolonged courtship (see above).

Male behavior to reject males. Males have no reason to reject females but may need to reject other males. In laboratory cultures of *Pieris brassicae*, where a male could not escape the attentions of another male, sometimes resting males gave the female Pieridae rejection posture when courted by other males (David and Gardiner, 1961). In *Precis coenia*, a teneral male may flutter his wings like the female rejection dance when courted by another male. The color of male *Hypolimnias* deters other males (Stride, 1956), but this species is sexually dimorphic unlike most butterflies. The vertical encounters between males described previously under perching behavior are attempts to elicit female behavior rather than rejection behavior.

Role of pheromones in courtship. Pheromones of one or both sexes are important in courtship of most species although only in Danainae have pheromones been chemically identified. In all species except the few using a long-distance pheromone, the pheromone is used only within one to two meters. Female pheromone evokes the male pursuing response and causes continued courtship, while the male pheromones may cause the female to land and accept the male. In *Pieris rapae* (Obara, 1970), *Hypaurotis*, *Hypolimnias* (Stride, 1956), *Argynnis paphia* (Magnus, 1958), *Hipparchia semele* (Tinbergen et al. 1942),

Papilio glaucus-group (Brower, 1959), and probably most species vision is more important early in courtship and pheromones are more important in later stages. In *Hypolimnna*, substitution of a male for the female in the later stages of courtship does not stop courtship, indicating that the visual difference between the sexes used earlier has no effect at close range.

There is behavioral evidence for male pheromones in Danaeinae, *Hipparchia semele* (Tinbergen et al. 1942), *Argynnis paphia* (Magnus, 1950), *Erynnis tristis* (Shields, 1967), and *Ithomia heraldica* (Lawrence Gilbert, written communication), and *Colias philodice* (Orley Taylor, oral communication). Pheromones have been isolated in three species of Danaeinae, and their mode of action determined (see isolating mechanisms below). Longstaff (1912) and Clark (1926) found strong male odors of hundreds of species; often these odors develop only after a few days and are strong in older males. Perhaps 50% of all butterfly species have male structures which presumably emit pheromones (Table 2). The organs of males are setae modified into long hairs gathered into tufts, or setae modified into scales of various types, including long tapered scales with terminal tufts called "androconia". These modified setae are associated with glands. The location in males is usually on the wings (especially the upperside of the forewings), but occasionally on legs or abdomen, because males often flutter during courtship, and they are usually behind the female. The function of androconia in *Hipparchia semele* was shown by excising the part of the wing containing androconia; such males had great difficulty in acquiring a mate (Tinbergen et al. 1942). In *H. semele*, *Argynnis paphia*, and *Erynnis tristis*, the male brings the androconial areas of the wing next to the female antennae. However, all three of these species have close relatives which either do not do this, or have the same courtship pattern and lack androconia. Such cases of direct contact between androconia and antennae are unusual, and in most cases the androconia are necessarily transmitted via air currents from male to female. In males of most groups except Danaeinae, Ithomiinae, some Papilionidae, and probably other groups, male pheromone-organs occur in one species and are absent in closely related species in a seemingly random fashion; thus only 26 of 69 *Erebia* species possess androconia (Warren, 1936); and in Nearctic *Erynnis*, one species has the tibial hair tuft only, six species have tibial tuft and front wing costal fold, and nine species have only the costal fold (Burns, 1964). It can

TABLE 2. Anatomical source of pheromones (Dixey, 1932; Illig, 1902; Gotz, 1951; Barth, 1944, 1952, 1959, 1960; Urbahn, 1913; Freiling, 1909; Eltringham, 1912; Kames, 1966; Clark, 1926).

Male	Hair-pencils	Female
tibial tuft on hind leg fits into thoracic pouch in many Pyrginae abdomen, and gland on hind wing in <i>Acraea thalia</i> , Danainae abdomen of <i>Melete</i> , <i>Morpho</i> hindwing of Ithomiinae, <i>Typhe-danus</i> , <i>Mycalesis mineus</i>		abdomen in Heliconiini, <i>Gonepteryx rhamni</i> , <i>Glutaphrissa saba</i> , <i>Catopsilia</i> , <i>Melete</i> , <i>Papilio machaon</i>
Modified Scales		
abdomen of Brassolini hindwing of <i>Stichophthalma camadeva</i> , some Papilioninae (<i>Parides</i> , etc.) patches on forewing in many Hesperinae fold on costa of forewing in many Pyrginae patches on both wings of many Pieridae		abdomen of <i>Euploea asela</i> underside of forewing in <i>Thymelicus lineola</i>
Androconial Scales		
scattered over wing in Pieridae, Lycaenini, Plebejini, <i>Erebia</i> small patch on front wing in many Theclini small patch on hind wing in some <i>Colias</i> large patch on front wing in many Satyrinae along veins of front wing in Melitaeini, Argynnini patches on both wings in many <i>Heliconius</i>		
Glands Not Associated With Modified Scales		
invaginated glands on abdomen in <i>Didonis</i> , <i>Argynnis</i> , <i>Heliconius</i>		external lobes near ovipositor in <i>Euchloe</i> , <i>Pieris</i> invaginated glands on abdomen in <i>Aglais urticae</i> , <i>Boloria</i> , <i>Argynnis</i> , <i>Vanessa</i> , <i>Didonis</i>

TABLE 3. Species for which female pheromones are suspected from behavioral evidence.

- Parnassius phoebus*, Scott, this study
Papilio glaucus-group, Brower, 1969; Scott, this study
Pieris napi, Petersen, 1952
Pieris protodice, Shapiro, 1970
Colias philodice, Stern & Smith, 1960
Gonepteryx rhamni, Lederer, 1938a
Glutaphrissa saba, Poulton, 1912
Oeneis jutta, Masters & Sorensen, 1969
Hipparchia semele, Tinbergen et al. 1942
Neominois ridingsii, Scott, this study
Euphydryas editha, Labine, 1966
Boloria sp., Eltringham, 1919
Coenonympha sp., Eltringham, 1919
Danaus gelippus, Brower et al. 1965
Heliconius erato (two pheromones), Crane, 1955; Lawrence Gilbert, oral communication
Heliconius charitonius, Edwards, 1881
Planema spp., Eltringham, 1912
Euphydryas anicia, Scott, this study
Argynnis paphia, Magnus, 1950
Chlosyne damoetus, Scott, this study
Precis coenia, Scott, this study
Hypolimnas misippus, Stride, 1956
Limenitis camilla, Lederer, 1960
Aglais urticae, Temple, 1953
Hypaurotis crysalus, Scott, this study
Glaucopsyche lygdamus, Scott, this study
Erynnis brizo, Burns, 1964
Hesperia pahaska, Scott, this study
Agathymus spp., Roever, 1964
Anthocharis, Lederer, 1941

TABLE 4. Sex which carries the other when a copulating pair is disturbed. *—both sexes have been recorded flying. Compiled from field observations by the present author (number of observations in parentheses); Lederer, 1938a, 1938b, 1941, Stellwaag, 1924; Rutkowski, 1971; Phipps, 1968; Crane, 1955; Tinbergen et al. 1942; Stride, 1956; Malicky, 1961; Poulton, 1918; Wheeler, 1915; McCubbin, 1971; L. E. Gilbert, oral communication; Shields & Emmel, 1973; and many references cited by the latter reference.

Male Flies

Pieridae: *Pieris rapae* (1), *P. beckeri*, *P. manni*, *P. sisymbri*, *P. occidentalis* (1), *P. brassicae*, *P. protodice* (2), *P. virginiensis*, *P. napi*, *P. doxo**, *Dixeia pigea*, *D. charina simana**, *Belenois gidica*, *B. creonia severina*, *B. mesentina*, *Appias drusilla*, *Herpaenia eriphia*, *Catasticta nimbece*, *Eurema lisa*, *E. desjardinsii regularis*, *E. brigitta*, *E. hecabe senegalensis*, *E. mexicana* (1), *E. nicippe*, *Anthocharis cethura*, *Colotis achine*, *C. evippe omphale*, *C. evagore*, *C. evenina casta*, *C. ducissa*, *Eronia cleodora*, *Catopsilia florella*, *Nathalis iole*, *Phoebus sennae* (1), *Pontia daplidice*, *Colias cesonja* (3), *C. edusa*, *C. hyale**, *C. philodice* (2), *C. eurytheme* (4), *C. palaeno*, *C. crocea**, *C. occidentalis*, *C. phicomone*, *Gonepteryx rhamni**, *Glycestha aurota*, *Pinacopteryx eriphia*

Nymphalidae, Danainae: *Danaus gilippus* (1), *D. plexippus*, *D. chrysippus*
Acraeinae: *Acraea caecilia*, *A. oncaea*, *A. caldarena**

Satyrinae: *Melanargia galathea**, *Maniola jurtina**, *Brintesia circe*, *Chazara briseis*

Nymphalinae, Heliconiini: *Heliconius erato* and many other *Heliconius* spp.

Argynniini: *Argynnis adippe**, *A. paphia**, *A. niobe**, *A. aglaja**, *A. atlantis* (4), *A. nokomis**, *A. lathonia**, *A. cybele**, *A. mormonia**, *Euptoieta claudia**

Boloria: *B. selene*

Melitaeini: *Melitaea diamina*, *Melicta athalia**

remaining Nymphalinae: *Biblia acheloia*, *B. goetzii*, *Anartia fatima*, *Phalanta phalanta*

Lycaenidae

Lycaeninae

Lycaenini: *Lycaena tityrus*, *L. arota**, *L. editha*, *L. subalpina*

Plebejini: *Cupido osiris*, *Syntarucus pirithous**, *Plebejus shasta**, *P. argyrognomon*, *P. argus*, *P. saepiolus** (1), *P. melissa** (1), *P. acmon** (2), *P. icarioides** (1), *Polyommatus icarus*, *P. eros*, *Plebicula escheri*, *P. dorylas*, *Meleageria daphnis*, *Lycaeides idas*, *Lysandra coridon*, *L. bellargus*, *Agraudes glandon** (3), *A. thetis*, *Hemiargus isola** (2), *Glaucopsyche alexis*, *G. lygdamus* (2), *Everes alcetas*, *Agrodiaetus damon*, *Albulina orbitulus*, *Aricia agestis*, *Philotes baton*, *P. battoides**, *P. enoptes**, *P. rita*, *Leptotes marina**

Hesperiidae

Female Flies

Papilionidae

Parnassius apollo, *Zerynthia polyxena*, *Z. rumina*, *Battus philenor* (1), *Papilio bairdii*, *P. polyxenes*, *P. p. rudkini*, *P. machaon*, *P. zelicaon*, *P. dardanus*, *P. polytes*, *P. echerioides*, *P. jacksoni*, *P. alcinous*

Pieridae

*Pieris doxo**, *Pieris* spp. (seldom), *Gonepteryx rhamni** (usually), *Aporia*

crataegi (based on 15 pairs), *Eurema nise* (1), *Ascia monuste*, *Dixeia charina simana**, *Colias hyale**, *C. crocea**

Nymphalidae, Acraeinae

Acraea chilo, *A. encedon*, *A. natalica*, *A. caldarena**

Satyrinae

Pyronia cecilia, *P. tithonus*, *Satyrus actaea*, *S. cordule*, *Satyre justina*, *Coenonympha arcania*, *C. gardetta*, *C. pamphilus*, *C. tiphon*, *C. satyrion*, *C. tullia* (1), *Erebia albertanus*, *E. oeme*, *E. manto*, *E. euryale*, *E. aethiops*, *E. gorge*, *E. claudina*, *E. goante*, *E. stirius*, *E. montanus*, *E. medusa*, *Melanargia galathea**, *Maniola jurtina**, *M. tithonus*, *Lastommata megera*, *L. maera*, *Hipparchia neomiris*, *H. semele*, *Ypthima asterope*, *Euptychia cycla*, *E. hermes*, *Aphantopus hyperantus*, *Pararge hiera*, *P. aegeria*, *Pierella luna*, *P. helvina*, *Cercyonis pegala* (9), *C. oetus* (2), *C. meadi* (2), *Neominois ridingsii* (2), *Oeneis chryxus* (3), *O. taygete* (1), *O. melissa* (1), *Minois dryas*

Nymphalinae, Argynniini

*Argynnis adippe**, *A. paphia**, *A. niobe**, *A. aglaja**, *A. pandora*, *A. nokomis**, *A. cybele** (1), *A. aphrodite*, *A. idalia*, *A. callippe* (1), *A. egleis*, *A. hydaspe*, *A. mormonia**, *A. edwardsi* (1), *A. lathonia**, *Euptoieta claudia** (1)

Boloria

B. daphne, *B. euphrosyne*, *B. pales*, *B. titania*

Melitaeini

Euphydryas aurinia, *E. chalcadon*, *E. editha*, *Melitaea cinxia*, *M. helvetica*, *M. didyma*, *Mellicta athalia**, *Poladryas minuta arachne* (9), *Phyciodes orseis* (1), *P. campestris* (4), *P. mylitta*, *P. tharos*, *Chlosyne gorgone* (3), *C. leanira fulvia* (1), *C. lacinia* (2), *C. californica*, *C. damoetas malcolmi*, *C. gabbi*, *Mellicta asteria*, *M. varia*, *Microtia dymas*

remaining Nymphalinae

Asterocampa leilia, *Anartia jatrophae*, *Limenitis bredowi*, *Hamanumidia daedalus*, *Pseudocraea poggei*, *Neptis agatha*, *Precis actia*, *P. coenia* (22), *P. clelia*, *P. villida*, *Hypolimnys misippus*, *Apatura iris*

Lycaenidae, Riodininae

Apodemia mormo

Lycaeninae, Theclini

Alaena interposita, *Axiocerses amanga*, *Hypaurotis crysalus* (1), *Satyrrium saepium* (1), *Harkenclenus titus*, *Nordmannia acaciae*, *N. ilicis*, *Strymonidia spini*, *Callophrys apama* (2)

Lycaenini

Lycaena hippothoe, *L. phlaeas*, *L. arota** (1), *L. helloides* (1)

Plebejini

Cupido minimus, *Syntarucus pirithous**, *Hemiargus isola** (1), *Plebejus icarioides** (1), *P. acmon** (1), *P. shasta**, *P. saepiolus** (1), *P. melissa** (1), *Agriades glandon** (1), *Maculinea arion*, *Cyaniris semiargus*, *Evers comyntas*, *Eumedonia eumedon*, *Leptotes marina**, *Philotes battoides**, *P. enoptes** (1)

Hesperiidae

Amblyscirtes simius (4), *Hesperia pahaska* (2), *H. juba*, *H. comma* (3), *H. ryffelenis*, *Thymelicus sylvestris*, *Polites coras*, *P. sonora*, *Adopaea thಾಮas*, *Euphyes conspicua*, *Hylephila phyleus*, *Cartharodus lavatherae*, *Erynnis telemachus* (2), *E. tristis*, *E. persius* (2), *E. tages*, *E. brizo*, *E. funeralis*, *E. juvenalis*, *Polythrix asine*, *Cogia calchas*, *Atrytone conspicua*, *Ochlodes sylvanoides*, *O. venatus*, *Pholisora catullus*, *Pyrgus alveus*, *P. carlinae*, *P. communis*, *P. malvae*, *P. serratulae*, *Thorybes diversus*

TABLE 5. Duration of copulation (*mate only during part of day).

- Parnassius phoebus* average about 3 hr., rarely 24 hr.; Scott, this study; Edwards, 1868
- Parnassius* spp. 1-12 hr., rarely 48 hr.; Lederer, 1938b; Edwards, 1868
- Zerynthia* sp. 1 hr.; Lederer, 1938b
- Graphium podalirius* $\frac{3}{4}$ to $1\frac{1}{4}$ hr.; Lederer, 1938b
- G. marcellus* 1 hr.; Lederer, 1938b
- Papilio machaon* $\frac{1}{4}$ to $2\frac{3}{4}$ hr.; Lederer, 1938b
- Papilio zelicaon* 36 min. up to 30 hr. if male mated recently; Shields, 1967; Lawrece Gilbert, unpublished
- Papilio xuthulus* 10 min.; Lederer, 1938b
- Papilio* spp. more than 10 min. and less than 3 hr.; Clarke & Sheppard, 1956
- Aporia crataegi* several hr.; Lederer, 1938b
- Pieris napi* 50 min. to 3 hr. depending on temperature, rarely 5 days at low temperature; Petersen & Tenow, 1954
- Pieris brassicae* 1 hr., up to 3.5 hr. at low temperature; David & Gardiner, 1961
- Pieris rapae* 80 min.; Obara, 1967
- Pieris* spp. 1-4 hr., rarely 1-2 days; Lederer, 1938b
- Pontia daplidice* 30 min.; Lederer, 1938b
- Euchloe hyantis* occasionally overnight; P. Opler, written communication
- Euchloe ausonides* 30 min.; Scott, this study
- Anthocharis* spp. $\frac{1}{4}$ to 4 hr., rarely to next morning; Lederer, 1938b
- Colias eurytheme* about 1 hr., Burns, 1970
- Colias eurytheme* X *interior* 67 min.; Burns, 1970
- Colias* (seven species) $\frac{1}{2}$ to $3\frac{1}{2}$ hr., most 2-3 hr., one 5 hr.; Lederer, 1941
- Gonepteryx rhamni* 1-3 hr., one case more than 28 hr.; Lederer, 1938a
- **Danaus gilippus* 100 min. to 12 hr., usually several hr.; Burns, 1970
- Hipparchia semele* 45 min. to 2 hr.; Tinbergen et al. 1942
- **Neominois ridingsi* average 15 min.; Scott, this study
- **Poladyras minuta arachne* average 35 min., range 15-82 min. ($N = 27$) lasted 9 hr. and 11 hr. when the male mated immediately prior to timed mating; Scott, this study
- Euphydryas editha* average 109 min. in field, average 61 min. and average 87 min. at 25°C in lab in two replicates, average 94 min. in lab if male recently mated, average 108 min. in lab if male mated twice before recently; Labine, 1966
- Chlosyne lacinia* about 45 min.; Drummond et al., 1970
- Limenitis camilla* 30 to 130 min., up to 5 hr. if temperature drops; Lederer, 1960
- Limenitis* spp. 45 min. to over 2 hr.; Platt, 1969
- **Aglais urticae* occasionally overnight; Poulton, 1904
- Precis coenia* average 33 min.; Scott, this study
- **Callophrys augustinus* 2-8 hr., usually 4-6 hr.; Powell, 1968
- **Nordmannia ilicis* 1 hr. or more; Fiori, 1957
- Poanes hobomok* average 38 min.; Burns, 1970
- Hesperia metea* 2 hr.; Shapiro, 1965
- Erynnis tristis* 61 min.; Shields, 1967
- **Agathymus* spp. 3-4 hr.; Roever, 1964
- Pieris protodice* frequently overnight; A. Shapiro, written communication

hardly be assumed that organs present in thousands of butterfly species are nonfunctional, yet we are faced with the presence or absence of the structures in closely related species. The random presence or absence and modifications of structure and placement of the organs are ideally suited for isolating mechanisms (see below). More studies are needed on the use of androconia.

Female pheromones probably occur in most species (Table 3). The evidence for pheromones consists of experiments in *Argynnis*, *Hypolimnas*, *Hypaurotis*, anatomical evidence in other species (Table 5), and field observations in the other species, including observations of males locating females hidden from sight, and differential behavior toward virgin or freshly mated females and older females, when no visual cues are given by the females to enable the male to discriminate. Clark (1926) described female odors of 54 species. The fact that in many species unreceptive females perform rejection dances while receptive females remain quiescent also argues for the presence of female pheromones, because in these species females give the male fewer visual cues if they are receptive than if unreceptive. The female can mate before the wings are expanded in many patrolling species (*Graphium marcellus*, Edwards, 1868; *Papilio rutulus*; *Parnassius phoebus*; *Pieris protodice*, Shapiro, 1970; *Colias philodice*, Stern and Smith, 1960; *Ascia monuste*, Nielsen, 1961; and *Heliconius*, Edwards, 1881); in most cases a patrolling male accidentally wanders within a few meters of the newly emerged female, and then detects the pheromone. The short distance in which these pheromones usually act may mean that in some species the male detects biochemical differences between the sexes or between young and old individuals rather than a specific chemical manufactured by the female for the purpose. In a few genera (*Precis*; *Heliconius* (Crane, 1955), young males also are somewhat attractive to other males, and in *Hypolimnas*, males possess the pheromone to about the same extent as the females (Stride, 1956). In most species, however, the pheromone seems limited to or greater in the female.

The anatomical source of female pheromones is shown in Table 2. In some species such as *Hypaurotis* and *Precis*, a female pheromone is behaviorally suspected, but there is no obvious source; general biochemical differences between the sexes may be utilized, or the glands may be small. The female pheromone sources are usually glands, which may be associated with hairlike setae, or hair-pencils similar to those of males (but

no species has similar organs in both sexes except for *Thymelicus lineola*, in which they are located differently and are only superficially similar). The glands are located almost always near the end of the abdomen, because the female usually keeps her wings motionless during courtship so that wing scales cannot become transmitted as well as those of males, and the male is almost always behind the female often with his head near her abdomen prior to joining.

Sound. Some butterflies produce sounds (male *Hamadryas*, Ross, 1963; *Megathymus* females, Scott, this study), but the function of these sounds is unknown; they may serve as intraspecific communication, because some butterflies hear (*Heliconius* and *Hamadryas*, Swihart, 1967a).

Prezygotic Isolating Mechanisms. Because few interspecific copulating pairs are found in nature, the visual and olfactory factors of courtship are probably very important as isolating mechanisms. Males can physically mate with females of very many species. So far, only color and odor have been shown to be important as isolating mechanisms. Because closely related species usually have similar courtship movements, these movements may not function as an isolating mechanism. In the *Papilio glaucus*-group, the color of the conspecific female is important for the initial approach by the male, and it is probable that pheromone of a conspecific female is needed for continued courtship (Brower, 1959). In *Pieris napi-bryoniae* complex courtship was a weak isolating mechanism, even though differences in female pheromones and coloration (but not the male pheromone) occurred (Petersen, 1952, 1954). *Danaus gilippus* male hair-pencils possess a pheromone which is effective only on female *D. gilippus* and not on female *D. plexippus* (Myers, 1968, 1970; Meinwald et al. 1969a, 1969b; Myers and Brower, 1969; Pliske and Eisner, 1969; Schneider and Seibt, 1969). Another Danaine, *Lycorea*, has male pheromones different from both *Danaus* (Meinwald et al. 1966). *Heliconius erato* and *H. melpomene* males are attracted to red, while *H. besckei* males are attracted to yellow (Emsley, 1970). *Colias philodice* and the related entity *eurytheme* have different male pheromones; newly emerged females are less selective than are older females (Orley Taylor, oral communication). Because females are mated at an earlier age at high density, amount of hybridization is probably greater at high density. In *Parnassius* and *Acraea*, in which there are many species of almost identical appearance, the absence of courtship seems to require

that species-specific pheromones are used, but no evidence is available. Mating of closely related species in different areas of the habitat, as in *Hesperia*, serves at least to reduce interference between species. Mating at different times of day would serve as an isolating mechanism, but I know of no very closely related species with non-overlapping mating times.

Copulating posture. Males of almost all butterflies grasp the female from a position slightly behind her by facing the same direction as the female and bending the abdomen right or left 180° to grasp her abdomen. Then the male moves laterally until both sexes face opposite directions. The male bends his abdomen right or left depending on his position; there are no known species which bend only one direction. In *Parnassius*, the male grasps the ventral part of the female's thorax with his legs and bends his abdomen toward her, or occasionally if a male is between the female's wings, both sexes twist their abdomens to form the same position. In *Ornithoptera brookeana*, the male somehow manages to grasp the female while she is dorsal to him (Skertchly, 1889).

Behavior during copulation. Apparently only in the Danaeinae is there a postnuptial flight (the male always carries the female a short distance). In other species the pair remain at the site of mating, where they may separately or both bask, or may fly if disturbed. If disturbed, the sex which carries the other is usually fixed within species (Table 4). In taxa in which only one sex carries the other, the active sex also positions itself above the other, positions its wings outside of those of the other (but in some species the wings do not overlap), and is more likely to walk during copulation. At the end of copulation in *Precis* the female kicks and turns until the male is broken off; then the male flies away. In *Papilio zelicaon*, the male initiates uncoupling (Shields, 1967). In *Poladryas*, the two individuals merely separate.

Duration of Copulation (Table 5) seems to be partly inherited and species-specific, and partly affected by temperature and prior mating by the male. In four species duration increases at lower temperatures; Petersen and Tenow (1954) even developed an equation for this relationship. In *Precis napi*, *Euphydryas editha*, *Poladryas*, and *Papilio zelicaon*, copulation lasts longer if the male mated in the previous two days. Increased duration just after prior copulation may partly explain the longer matings of *Danaus* spp. (Burns, 1970) and *Callophrys augustinus* (Powell, 1968), which mated frequently. Long copu-

TABLE 6. Number of matings per male

Can mate at least twice

- Papilio zelicaon*, Lawrence Gilbert, oral communication
Papilio machaon, Clarke & Sheppard, 1956
Papilio glaucus, Clarke & Sheppard, 1956
Papilio dardanus, Clarke & Sheppard, 1956
Pieris rapae, Shapiro, 1970
Pieris napi, Petersen & Tenow, 1954
Precis coenia, Scott, this study
Gonepteryx rhamni, Lederer, 1941

Can mate at least four times

- Limenitis camilla*, Lederer, 1960
Danaus plexippus (can also mate twice per day), Burns, 1970
Euphydryas editha (can mate on successive days), Labine, 1966
Limenitis spp. (mate most readily on alternate days), Platt, 1969
Pieris brassicae (sometimes twice per day), David & Gardiner, 1961
Acraea encedon (can mate on successive days), Owen, 1966

Can mate at least five times

- Poladryas minuta arachne* (can mate on successive days and twice per day), Scott, this study
Colias eurytheme (can mate on successive days), Stern & Smith, 1960
Callophrys augustinus (can mate on successive days), Powell, 1968
Papilio eurymedon (can mate on successive days), Clarke & Sheppard, 1957

Can mate at least ten times

- Heliconius* sp., Lawrence Gilbert, oral communication

Can mate at least 13 times

- Pieris protodice*, Arthur Shapiro, written communication

lation in *Parnassius* may be needed to deposit the sphragis, a large structure deposited by the male preventing further mating. Species which mate only during part of the day might be expected to have shorter copulations, but this does not occur (Table 5). It is unlikely that copulation is prolonged until the female loses receptivity to other males, because in *Euphydryas editha* females reject males immediately after mating due to the presence of the spermatophore (Labine, 1966), and in the moth *Attveva punctella*, presence of the spermatophore itself caused short-term unreceptivity to males (Taylor, 1967).

Number of matings per male. The data available suggest that males can mate on successive days, and up to five times (rarely 13 times) per male, although males may mate more readily on alternate days (Table 6). Males which produce a large sphragis or large spermatophores probably mate less often due to depletion of the accessory glands.

Number of matings per female. In contrast to males which show little difference in mating frequency between species, the number of matings per female varies greatly between species (Table 7). Extremes are *Parnassius*, which never mates more than once, and *Danaus gilippus*, which can mate up to ten times. In the multiple mating species, number of matings depends on age (*Euchloe ausonides*, *Pieris brassicae*, *Colias philodice*, *Precis coenia*, *Hesperia pahaska*, *Amblyscirtes simius*, and *Ochlodes snowi*); only in *Hypaurotis* is this relationship weak. In *Pieris brassicae* the effective period between matings is six to nine days.

A sphragis is known in Acraeinae (*Planema*, *Acraea*, *Actinote*), Danainae (*Amauris*), and Papilionidae (*Parnassius*, *Thais*, *Luehdorfa*, *Eurycus*, *Cressida*, *Papilio plutonius*, *P. priabus*, and *Euryades*) (Eltringham, 1912; Lederer, 1938b). Males of these species probably mate less frequently than males of other species because males of *Parnassius* use the accessory gland fluid to form the sphragis (Eltringham, 1925) so several matings would deplete the glands. Owen & Chanter (1969), however, found that *Acraea encedon* males mate up to four times. In *Acraea thalia* males, the male has a hair pencil similar to *Danaus gilippus* which becomes almost completely incorporated into the sphragis (Eltringham, 1912); if these hairpencils are used in courtship as seems likely, the male would be able to mate only once or twice.

In all the species with a large sphragis, many similarities exist, including the absence of courtship, powerful odor of adults

TABLE 7. Average number of matings per mated female. Because number of matings depends on age in multiple-mating species, some of these averages may be too low. Number of matings per old female would be a better measure, but this was determined only by me. *—perching species. ?—may be a perching species. Others patrolling.

<i>Parnassius phoebus</i>	1.00	Scott, this study
<i>Parnassius clodius</i>	1.00	Shields, 1967
<i>Acraea</i> spp.	1.00	Eltringham, 1912
* <i>Lycaena arota</i>	1.02	Scott, this study
* <i>Poladryas arachne</i>	1.03	Scott, this study
* <i>Neominois ridingsii</i>	1.03	Scott, this study
* <i>Polites sabuleti</i>	1.03	Shields, 1967
<i>Heliconius erato</i> almost always once		Crane, 1955
? <i>Pseudocopaeodes eunus</i>	1.04	Shields, 1967
<i>Cercyonis pegala</i>	1.04	Burns, 1968
<i>Speyeria cybele</i>	1.05	Burns, 1968
? <i>Poanes viator</i>	1.06	Burns, 1968
* <i>Limenitis camilla</i> sometimes twice		Lederer, 1960
* <i>Atalopede campestris</i>	1.07	Burns, 1968
<i>Speyeria callippe</i>	1.08	Shields, 1967
? <i>Thymelicus lineola</i>	1.09	Burns, 1968
<i>Anthocaris sara</i>	1.09	Shields, 1967
* <i>Lycaena xanthoides</i>	1.10	Scott, this study
? <i>Wallengrenia otho</i>	1.13	Burns, 1968
<i>Coenonympha tullia</i>	1.15	Shields, 1967
* <i>Hesperia pahaska</i>	1.15	Scott, this study
* <i>Amblyscirtes simius</i>	1.15	Scott, this study
* <i>Precis coenia</i>	1.17	Scott, this study
<i>Chlosyne acastus</i>	1.19	Shields, 1967
<i>Papilio zelicaon</i>	1.24	Shields, 1967
<i>Colias philodice eurytheme</i>	1.30	Stern & Smith, 1960
<i>Euchloe ausonides</i>	1.32	Scott, this study
<i>Hypaurotis crysalus</i>	1.33	Scott, this study
* <i>Polites mystic</i>	1.33	Burns, 1968
<i>Erebia epipsodea</i> usually once, up to 3 times		Brussard & Ehrlich, 1970
* <i>Hesperia sassacus</i>	1.34	Burns, 1968
<i>Euphydryas editha</i> often twice, up to 3 times or more		Labine, 1964
* <i>Epargyreus clarus</i>	1.44	Burns, 1968
* <i>Euphyes vestris</i>	1.45	Burns, 1968
* <i>Ochlodes snowi</i>	1.65	Scott, this study
<i>Battus philenor</i>	1.73	Burns, 1968
<i>Papilio glaucus</i>	1.73	Burns, 1968
? <i>Lerema accius</i>	2.03	Burns, 1968
<i>Pieris brassicae</i> (10 days old)	2.30	David & Gardiner, 1961
<i>Pieris protodice</i> more than once often		Shapiro, 1970
<i>Danaus gilippus</i>	2.63	both <i>Danaus</i> from Burns, 1968
<i>Danaus plexippus</i> sometimes 2 times per days, up to 4 times at least		
<i>Pieris rapae</i>	2.66	Burns, 1968

of both sexes, and strong attraction of males to virgins. The male captures the female without any courtship in *Acraea*, *Planema* (Eltringham, 1912), and *Parnassius*. *Parnassius* and *Acraea* and probably most of the above have a female pheromone. Eltringham (1912) suggests that the large sphragis serves to inhibit the emission of the female pheromone in *Acraea*. In *Parnassius*, recently mated females are still attractive, but older mated females are not, so the same result is achieved as in *Acraea*. Other species of butterflies have a small plug in the copulatory orifice (Melitaeinae, some Hesperinae, and others) but the plug is often ineffective in preventing multiple mating, and courtship occurs.

Because males which plug the female will fertilize all her eggs, individuals of that genotype will increase in the population, even though this may reduce the viability of the population by reducing the number of recombinations. Capture of the female may be selected for because the male can always tell whether the female is virgin or mated by physically detecting the sphragis (or because of pheromone); if he detects that she is virgin, he can then mate immediately without wasting time courting. In other butterflies, determining the receptivity of the female may not be so easy, and one function of courtship is to increase the female's receptivity so that mating can occur. Capture may occur in *Parnassius* because the male must assume the venter-to-venter position in order to deposit the sphragis, which requires positioning the male using the legs. *Parnassius* and *Acraea* contain many species of similar appearance, so that the absence of courtship and female movement before copulation seems to require species-specific pheromones to prevent interspecific mating. The fate of sperm in the female is important; in most species sperm from the last mating fertilizes all the eggs (see below) which implies that males of all species would benefit genetically from "capture" of the female, and that the above factors rather than physiology must explain lack of courtship. The use of a sphragis may be rare because of energetic demands on the male.

Fertilization by different matings. Sperm from the last mating almost always fertilizes all the eggs laid by a female after that mating and until the next mating. This was shown in butterflies in *Papilio bianor* and *P. maackii* (Ae, 1962); *Papilio machaon*-group and *P. dardanus* (Clarke & Sheppard, 1962); *Euphydryas editha* (Labine, 1964); *Pieris rapae* (Shapiro, 1970). In moths, Taylor (1967) showed the phenomenon in *Atteva punctella*.

Significance of multiple mating. Mating with a non-virgin female is advantageous to the male (but less so than mating with a virgin) because all the female's subsequent eggs will be fertilized by him. Multiple mating is advantageous to the female to counteract previous infertile matings. In species with large spermatophores, I believe multiple mating also serves a nutritive function, perhaps permitting more eggs to be laid; in the moth *Galleria* digestion by proteolytic enzymes is completed by ten days (Chapman, 1969). A spermatophore may occupy a tenth or a fifth of the abdominal volume, and older spermatophores shrink until only remnants and the persistent "neck" remain, so that most of the spermatophore is absorbed and contributes to metabolism. Multiple mating may equalize sexual selection on both sexes by making the variance of number of matings per individual more similar in the two sexes; in species in which most females mate only once, the variance of number of matings per male will be much greater than in females so sexual selection will act more strongly on males. Color might be subject to sexual selection, but there seems to be no correlation of color or sexual dimorphism with frequency of mating (Table 7). Since females often mate near the site of emergence, females which mate only once will contribute more gene flow after immigration than females which mate again after emigration (Labine, 1964). However, species in which most females mate only once have a greater probability of genetic drift, since a smaller number of recombinations will occur than in species which can mate many times. These two forces oppose each other.

SUMMARY

There is tremendous diversity of wing, antenna, and body movements during courtship. Females can mate on the day of emergence, but males do not mate for several days. Visual factors important during courtship include movement, size, and general color. Unreceptive mated females reject males by a variety of stereotyped flight patterns (rejection dances) or stationary body postures (rejection postures) and occasionally by use of a repellent pheromone. Pheromones are common in both sexes and are used primarily as aphrodisiacs within a meter of the recipient. Male pheromones are generally produced on the wings, legs, or rarely on the end of the abdomen, while

female pheromones generally are produced on the end of the abdomen. Color and odor are important as isolating mechanisms. Males generally grasp the female to mate by bending the abdomen 180° laterally. Only one sex flies if a copulating pair is disturbed in most taxa; in a few taxa either sex may fly. Copulation lasts about ½ to 3 hours depending on the species, occasionally overnight (rarely 5 days). Copulation is longer at lower temperature and if the male recently mated. Males can mate five times or more, whereas number of matings per female varies greatly between species from only once to an average of three. A large sphragis, which prevents multiple female mating, is associated with lack of courtship and presumed pheromones of virgin females. The last mating usually fertilizes all subsequent eggs in multiple-mating females. Multiple mating serves a nutritive function in providing extra protein for oogenesis, it counteracts previous infertile matings, and it lessens the amount of gene flow after dispersal of the female.

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The Butterflies of Georgia, Lucien Harris Jr., 1972. University of Oklahoma Press, Norman; 326 pp, 23 pls (10 color); \$7.95.

This volume presents data of considerable interest to those interested in the geographical distribution of North American butterflies. Georgia, situated geographically as it is, has a mixture of both northern and southern species. The author, aware of the importance of Georgia from the distributional point of view, has presented extensive data dealing with occurrences in the Mountain, Piedmont and Coastal regions together with date of captures, food plants and general ecology.

The literature has been well covered with well-written digests of some of the more important contributions to the ecology of particular species.

The taxonomy has been brought up to date with a note concerning previous designations.

In addition to the value of this work to the professional Lepidopterist, it is also of considerable interest to the amateur; common names, where applicable, have been given without in any way distracting from the accuracy of the scientific name and the description. In addition, the author has added the naturalist's touch, unfortunately absent in so many modern lists, by describing his personal experiences in the field.

The Butterflies of Georgia is a valuable addition to the library of all interested in butterfly ecology and takes its place along with other state books such as those for Florida, Colorado, California and Virginia.

F. A. Urquhart

NOTICES

WANTED:

To borrow material of the genus Papaiperna (Noctuidae) for study. Preparing generic revision; need western material especially. Eric L. Quinter, R. D. 1. Auburn, Penna. 17922.

Orders solicited for named Macrolepidoptera and other insects. Some stock on hand. Stanley G. Jewett, Jr. Rt. 1, Box 339, West Linn, Oregon 97063.

Sphingidae of the world. Need especially Euproserpinus euterpe and E. vega. Wm. E. Sieker, 119 Monona Ave., Madison, Wis. 53703.

LITERATURE RECEIVED:

Marrow Monographs (Zoology): Evolution in the Arachnida, T. H. Savory, U. S. /Canada \$ 4.00. Biology of the Cryptozoa, Theodore Savory, \$ 4.00. Latin and Greek for Biologists, T. H. Savory, \$ 4.00. The Principles of Mechistic Biology, T. H. Savory, \$ 4.00. The Temperature and Water Relations of Reptiles, J. L. Cloudsley-Thompson, \$ 4.00. Marrow Publishing Co. Ltd. Watford, Herts, England WD1 or Bonn Industries, 266 Lake Ave. P.O. Box 178, Metuchen, N. J. 08840. U. S. A.

What Butterfly is That? C. G. C. Dickson, Purnell Pocketbook, South Africa Series, Capetown, South Africa.

An Index to the Described Life Histories, Early Stages, and Hosts of the Macrolepidoptera of the Continental United States and Canada. 2 vols. H. M. Tietz. Pub. by A. C. Allyn, Sarasota, Florida. Distr. by Entom. Reprint Specialists, P. O. Box 77971, Dockweiler Station, Los Angeles, Calif. 90007.

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Tropical Butterflies, D. F. Owen. Clarendon Press, Oxford. \$13.75. Oxford Univ. Press, 200 Madison Ave. N. Y., N. Y. 10016.

A Field Guide to the Butterflies and Burnets of Spain. W. B. L. Manley and H. G. Allcard. E. W. Classey, Ltd. Hampton, Middlesex, England. Distr. in U. S. A. by Entom. Reprint Specialists, P. O. Box 77971, Dockweiler Station, Los Angeles, Calif. 90007. \$ 37.50.

Hewitson on Butterflies 1867-1877. Pref. by L. G. Higgins. E. W. Classey and E. R. S., see above.

Butterflies of the Australian Region, Bernard D' Abrera. Lansdowne Press, 37 Little Bourke St. Melbourne, Australia. Distr. in U. S. A. by Entom. Reprint Specialists, as above. \$39.95.

Jamaica and its Butterflies, F. M. Brown and B. Heineman. Classey and Entom. Rep. Spec., as above. \$ 44.00.

Japanese Butterflies (in Japanese), Hoikusha Pub. Co. 20, 1-chome, Uchikyuhoji-machi, Higashi-ku, Osaka, 540, Japan.

Butterflies of Georgia, Lucien Harris, Jr. Univ. of Oklahoma Press, Norman Oklahoma.

Butterflies of the San Francisco Bay Region. Univ. of Calif. Press, Berkeley and Los Angeles, Calif. U. S. A. \$ 1.75.

Noctuidae of North America, A. R. Grote, 1882, E. W. Classey, Ltd., 353 Hanworth Rd., Hampton, Middlesex, England. Distr. in U. S. A. by Entom. Rep. Spec. (see above). \$ 16.95.

Mariposas de Venezuela, M. Schmid and B. M. Endicott, in Spanish and English, Calproven C. A. Apartado 5537 Chacao, Caracas, Venezuela. In U. S. A. by Entom. Repr. Spec. (see above)

Butterflies of Trinidad and Tobago, Malcolm Barcant. Collins, St. James Place, London. 55s.

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IN THIS ISSUE

- | | | |
|--|--------------------|-----|
| The Neotropical Nymphalid Butterfly,
<i>Anartia amaltha</i> | Michael K. Fosdick | 65 |
| On the distribution of
some Skippers in Ontario | J. C. E. Riotte | 81 |
| Observations on life history of
<i>Oarisma powesheik</i> (Parker) 1870 | Wilbur S. McAlpine | 83 |
| Habitat: <i>Oeneis jutta ascerta</i>
Masters & Sorensen | John H. Masters | 94 |
| Dispersal in a cosmopolitan
butterfly species (<i>Pieris rapae</i>)
having open population structure | Thomas C. Emmel | 95 |
| Mating of Butterflies | James A. Scott | 99 |
| Book Review —
Butterflies of Georgia | F. A. Urquhart | 128 |

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GYNANDROMORPHISM IN *PIERIS BRASSICAE* L.

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SYNOPSIS

An account is given of the appearance of gynandrous specimens of *Pieris brassicae* in various bred cultures. The influence of granulosis virus as a causative agent of these and other varietal forms is discussed.

INTRODUCTION

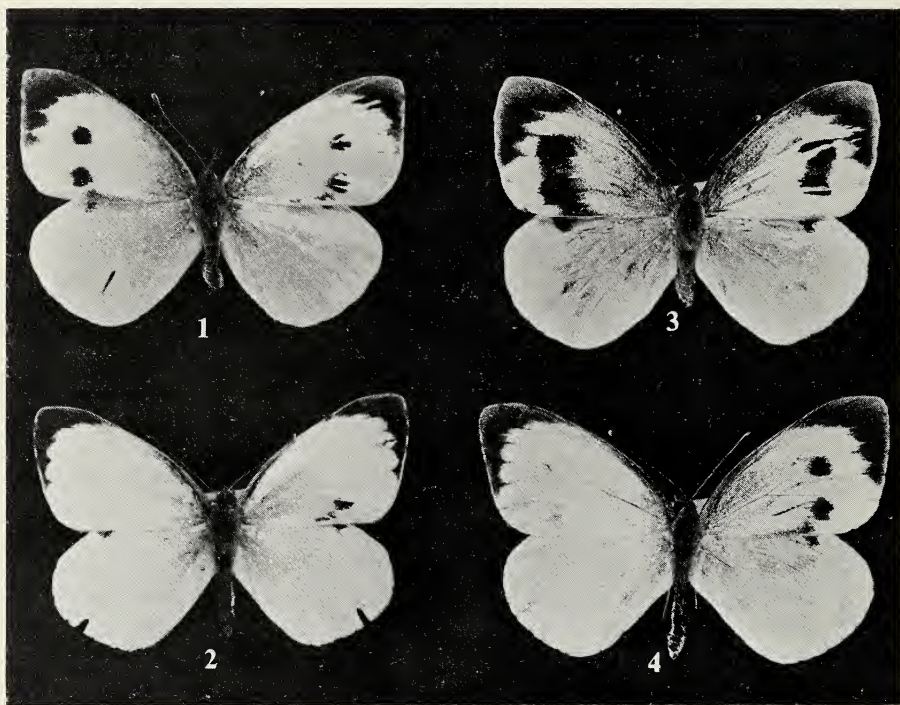
Pieris brassicae L. (the Large white butterfly) is a common and widespread Palaearctic species but, like other Pieridae, gynandromorphism is very rare (Frohawke 1934). For eighteen years (about 150 generations) a culture was maintained by the former A.R.C. Unit of Insect Physiology and this has been designated the Cambridge stock (David and Gardiner, 1960). In this stock a number of varieties were observed from time to time (David and Gardiner, 1961; Gardiner, 1962; 1963).

Since the report of two mixed gynandromorphs (David and Gardiner, 1961) one further example was found in this stock. No fully halved specimens at all were noted in the quarter million or so insects that it was estimated were bred. It has been reported by Frohawk (1934) that the late H. W. Head found two examples in the related *P. napi* L. out of 50,000 bred over a period of twenty-five years.

Recently some wild collected larvae of *P. brassicae* were received from near Hereford; this is designated the Hereford stock. In the F2 of these a considerable number of mixed gynandromorphs appeared. Attempts to breed from these were unsuccessful and the stock has now been discontinued. In addition to producing these gynandromorphs, this stock also produced specimens of *ab*, *fasciata* Frohawk and various intermediate forms. These form the subject of a separate paper (Gardiner, in preparation).

The so-called virus free stock (David and Gardiner, 1966a) had already produced a new recessive variety (Gardiner 1963) and in 1968 a halved gynandromorph was found in this stock after it had had an outbreak of granulosis virus disease.

In 1966 a partial gynandromorph was discovered in some hybrids between *P. brassicae* and *P. brassicae cheiranthi*. These hybrids are designated the *cheiranthi* stock.



Figs. 1-2.—The Cambridge stock gynandromorphs.

Fig. 3.—The *Cheiranthi* stock gynandromorphs.

Fig. 4.—The Virus-free stock bilateral gynandromorph.

THE CAMBRIDGE GYNANDROMORPHS

The Cambridge stock was established in 1950 from wild collected eggs and larvae. It has been reared continuously at the rate of about 8 generations per year since. The original method of rearing as described by David and Gardiner (1952) was latterly somewhat modified and the most recent, and well illustrated, account of the rearing methods employed is that quoted by Newman (1965) with the correction that the 24°C temperature there quoted was only maintained during the day. At night it was allowed to drop between 10-15°C. For five years this stock was bred without trouble and then in 1955 granulosis virus disease broke out killing some 95% of the larvae but four years later the attack had not only died down, but the stock had become resistant. (David and Gardiner 1960). In November 1960 however there was a further outbreak of virus disease, which had died out by the following year, but it again broke out in November 1962. From 1964 until 1968 however this stock was free of virus disease.

Descriptive. As already mentioned, only three Cambridge examples have been noted. The first of these has been previously described (Gardiner, 1957). (Fig. 1). Essentially female, with extensive bands of male scales on both right forewing and hindwing. The genitalia of this specimen are female, but there is in addition a small male clasper on the right hand side.

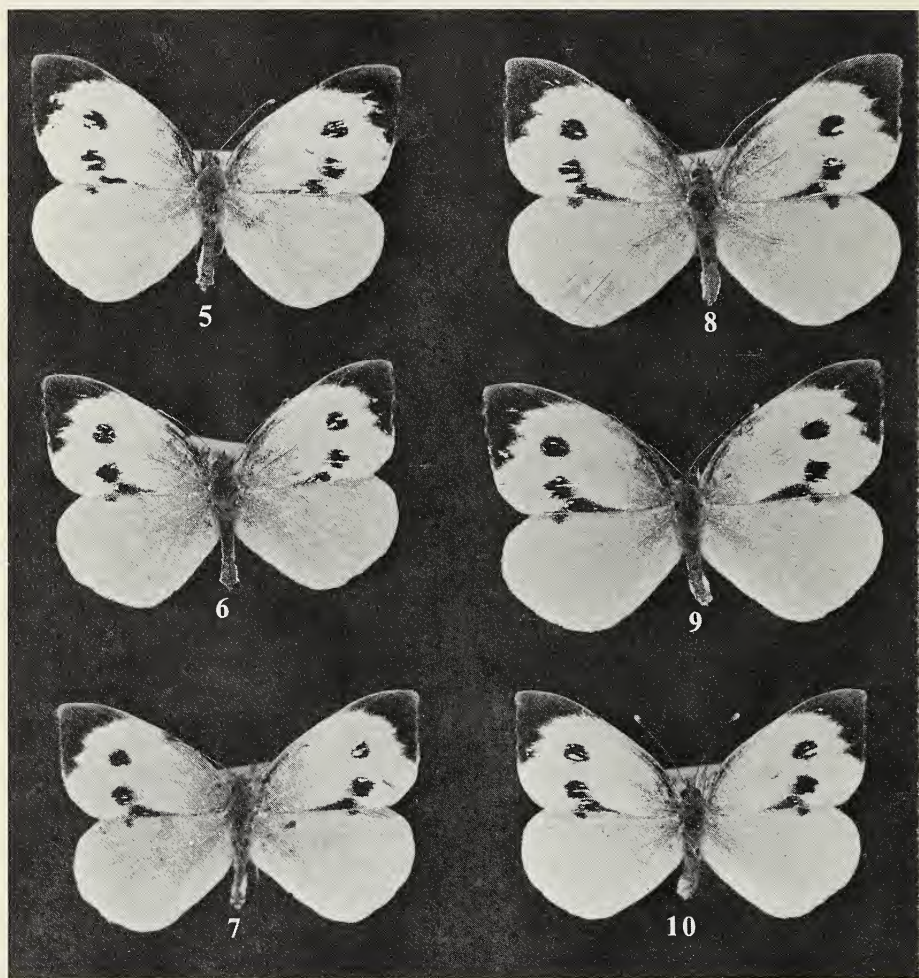
The second specimen is largely male, but with the left forewing with long streaks of female scaling on the costal half and the costal female forewing spot largely present. The genitalia are male.

This specimen is in the collection of C. F. Rivers, Esq.

The third specimen emerged 26.iii.1963. It is essentially male, with on the hind margin of the right forewing a band of female scaling extending irregularly from the base. About one half of the hindmargin spot and a trace of the streak are present. The genitalia are male (Fig. 3).

THE HEREFORD STOCK

This stock was collected as larvae by Mr. K. J. Coghill at Canon Frome, about eight miles from Hereford and the larvae, in various instars, arrived in Cambridge 17.IX.65. These were designated the Parent Hereford generation. They formed part of a collection of wild larvae from various localities which



Figs. 5-10.—Six examples of the Herefordshire stock gynandromorphs.

were to be tested for resistance to granulosis virus disease. These larvae originated from at least four separate egg batches and produced a total of 231 pupae. The butterflies from these pupae were allowed to mate at random to produce the F₁. A random selection of the 2nd instar larvae of this generation were treated with granulosis virus by methods already described (David & Gardiner, 1965), at concentrations of 10^{-4} ; 10^{-5} ; 10^{-6} . Out of a total of 231 larvae set up and reared singly 23% died of virus. The adults were again pooled and allowed to mate at random to produce the F₂. At the same time a number of untreated controls were set up. None of these died of virus disease, nor did any gynandromorphic specimens appear in either the F₂ or F₃ of these controls.

The mating responses of these F₁ adults was very poor and it is likely that the F₂ generation originated from only three or four adults. Every egg laid was reared and no deaths from virus disease were recorded. A total of 526 pupae were obtained from 17 separate egg-batches. These egg batches had been laid over a period of seventeen days, and the number originating from any one female was not known. These F₂ larvae were reared in jam-jars containing 15-20 larvae each, and the distribution of each egg batch was known. Of the total of 526 pupae, 42 of the resultant adults were mixed gynandromorphs.

Eight of the gynandromorphic specimens were put into a large mating cage with several dozen of their sibs and cousins. None of them lived for more than a week although it was noticed that the butterflies were feeding and, to make sure, they were also hand-fed. No pairings were observed or eggs (even infertile) obtained. Normally butterflies under these conditions live for a mean of 18 days (David & Gardiner, 1961). The remaining sibs and cousins were placed in a separate cage. These behaved in all respects like the long established Cambridge stock (David & Gardiner, 1961); no difficulty at all being experienced with feeding, pairing or oviposition. A small proportion of the tens of thousands of eggs laid were reared. No gynandromorphic adults were noted. A few random matings were taken and about 500 F₄ adults produced. None of these either were gynandromorphic.

Descriptive. The Herefordshire gynandromorphs are all of the same type; female with all four wings sprinkled, to a greater or lesser extent, with 'islands' and in some cases streaks of male androconial scales. This scattering is quite haphazard,

there is no uniformity either between wings or specimens. The male scales extend across both the female spots and hind marginal streak and also into the apical blotches, but never right to the wing margins. A selection of these is shown in Figs. 6-11. The genitalia of six specimens examined in detail were female. It may perhaps be significant that no ova were present in two examples immediately after death, although the oviducts and embryos were.

THE VIRUS-FREE STOCK

An account of this stock which originated in Oxford has already been given (David & Gardiner, 1966a). However, in 1968 virus disease again appeared in this stock as well as in the Cambridge stock, after both had been free of virus disease for some years. It should be noted, however, that the disease appeared among those larvae reared on cabbage, and not among those reared on the artificial diet used by David & Gardiner, (1966b). Some two generations after the re-appearance of virus in this stock a perfect halved gynandromorph was found. All sibs and all the following generation of several hundred insects was checked carefully without further result except that, it was noticed there had been a change in the general facies of the stock, the adults since the virus outbreak being rather larger and with more extensive and denser black markings than they had had previously.

Descriptive. The virus free gynandromorph emerged 20.-VII.1968. This example is a complete (including genitalia) bilateral. Left side male, right side female. (Fig. 4).

THE CHEIRANTHI STOCK

Although this stock has been previously commented upon (Gardiner 1965) and used for experiments with virus disease (David and Gardiner 1965) a full history of its antecedents has not been given. As has already been shown (Gardiner 1965) it was not possible to maintain a pure-bred *Cheiranthi* stock for more than a few generations. The stock known as the *Cheiranthi* stock is in fact a hybrid strain and its genetic history is summarised in Fig. 1. The stock is very susceptible to virus disease (David and Gardiner 1965) and it has been shown that the mortality is always higher when the larvae are fed on cabbage (David, Gardiner and Clothier 1968).

Descriptive. The *Cheiranthi* stock has shown considerable variation and produced many unusual forms. The only gynan-

dromorph found occurred amongst some cabbage-reared stock and emerged 20.x.1966. Essentially female with the hind margin and basal area of the right forewing largely male; a streak of male along the foreedge of the right hindwing and a small area of male on the outer area. (Fig. 2).

DISCUSSION

In the R-C-K collection of British Lepidoptera at the British Museum (Natural History), there are two *P. brassicae* gynandromorphs, one bilateral and in poor condition, the second with the costal female spot partially developed on the left forewing of an otherwise male specimen (Goodson, *in lit.*) I have seen two other specimens; exact details of these are not available, but they are similar to the R-C-K specimens, one being a bilateral example while the other is mixed on one side only. With the exception of the Hereford stock all the gynandromorphs described in this paper are of this same type. The Hereford gynandromorphs on the other hand, are all essentially females but strewn with some male patterning on all four wings.

The distribution of these gynandromorphs was rather curious. No record was kept of the actual number from any individual rearing jar, only the number of the actual jar in which any appeared. As can be seen from Table 1 any one egg-batch produced gynandromorphs in one jar only, irrespective as to whether it was contained in one jar (eggbatch D, which produced 16 pupae) or had been split into 3 jars (eggbatch M, which produced 57 pupae).

No theory can be advanced to account for this. When the eggbatches hatched the entire lot of larvae were pinned onto a fresh leaf in one jar. When the larvae were about two days old they were redistributed, quite randomly, between other jars as is shown in Table 1. Since the average number of gynandromorphs per jar was 5.25 and the average number of pupae 17, it is surprising that under these conditions the distribution was not more uniform.

However, the fact remains that this stock, in the space of one week, produced more gynandromorph specimens than the Cambridge stock in eighteen years or indeed than the total previously recorded in *P. brassicae* and it would seem certain a different genetic upset was operating. The Hereford stock was certainly carrying genes not present in either the Cambridge

TABLE 1

Distribution of Hereford gynandromorphs in the various rearing jars.

<i>Jar No.</i>	<i>Eggbatch</i>	<i>Total Pupae</i>	<i>Gynandromorphs present in jar.</i>
166-168	B	50	167
169-170	C	28	169
171	D	16	171
175-176	H	39	176
177-178	I	37	178
179-180	J	39	180
199-200	K	27	199
202-204	M	57	202
17	8	293	8

TABLE 2

The occurrence of virus and the discovery of gynandromorphs and varietal forms in various stocks of *Pieris*.

<i>Date of virus outbreak*</i>	<i>Stock</i>	<i>Variety found</i>	<i>Date found</i>
1924-25?	Wild	gynandromorph	1925
	H. W. Head's	gynandromorph	1926
	<i>P. napi</i>	gynandromorph	1927
	Aberdeen	numerous varieties	1926-29
1955	Cambridge	gynandromorph	1956
1960	Cambridge	ab albinensis	1960
1960	Virus-free	ab jauni	1961
1962	Cambridge	ab coerulea	1962
	Cambridge	gynandromorph	1963
Parents virus treated	Hereford	gynandromorph	1965
Endemic	Cheiranthi	gynandromorph	1966
1968	Virus-free	gynandromorph	1968

*After 1955 virus disease has been endemic. The dates are of major outbreaks. Where the virus and variety occur in the same year the virus preceded the variety by at least one generation.

or virus-free stocks for not only did it produce specimens of ab *fasciata* but various intermediate and variable forms. The stock was clearly in a state of some genetic flux.

An analysis of the dates of discovery not only of the gynandromorphs but also of the three other varietal forms, ab *jauni*, ab *albinensis* and ab *coerulea* which have been shown to be due to simple recessive alleles (Gardiner 1962; 1963) reveal the fact that in all cases the gynandromorph or varietal form, was preceded by an outbreak of granulosus virus disease. The theory is now put forward that the granulosus virus disease of the genus *Pieris* is capable, under certain conditions, of causing genetic mutation and indeed it may be that virus disease is the cause of many of the varieties to be found in the Lepidoptera for it is now well known that nearly all Lepidoptera suffer from time to time of various virus diseases.

It is quite clear even so that such genetic damage must be of rare occurrence and it may only be brought about by a combination of factors. In the case of the Hereford stock the larvae of the parent generation had been deliberately fed active virus. Now this particular type of experiment had been performed on a number of previous occasions on the virus-free stock without producing any gynandromorphs although other varietal forms did appear from time to time. However the virus free stock had been very stable genetically over several years, whereas the Hereford stock was already in a very unstable genetic condition. Its previous history of disease was of course not known. Also, all experimental efforts to produce naturally transmissible virus ended in failure, but when naturally occurring virus disease struck down any of the stocks, transmission over several generations also took place and indeed naturally occurring virus can, after over 30 generations be produced at any time in the *Cheiranthi* stock by submitting it to unfavorable environmental conditions. Since the virus disease may reappear after being in abeyance over several generations the seeds of it must be in or on the egg and hence closely associated with the genital mechanism. There is indeed also some evidence from *Cheiranthi* and other hybrids that virus disease may be transmitted through the male line and indeed even behave as if it were under some form of genetic control.

The two specimens in the R-C-K collection are dated 1950 and 1925. There is no direct evidence available as to whether *P. brassicae* suffered from virus disease prior to 1950, or indeed prior to 1925, but Paillot in 1926 described a disease that would

appear to be what is today known as the granulosis virus of *Pieris*. It may also be significant that the two gynandromorphs of *P. napi* bred by H. W. Head occurred in 1925 and 1926 (Frohawke, 1934). Also highly significant is the high percentage of observations obtained in the years 1927-1929 by Graham-Smith and Graham-Smith (1929) from Aberdeenshire. This is in contrast to the failure of Adkin, 1918 who examined "many hundreds, possibly thousands," and who, with one exception failed to find any variation and Verity (1916) states that "The migratory habits of *P. brassicae* have probably contributed in maintaining the lack of variation in any of them."

Unfortunately Graham-Smith and Graham-Smith do not give any indication of their larval mortality, only that the proportion of larvae parasitised was low. Moss (1934) however, had a larval mortality of nearly 60 per cent from disease. Even allowing for the fact that this total included escapees and accidents at least half of his larvae died. Although Moss assumes that this was bacterial disease it is this author's experience, having reared very many times the number of *P. brassicae* larvae that Moss did, that only granulosis virus disease could produce such a high mortality. There is, therefore very strong, but perhaps rather circumstantial evidence, that there was an outbreak of virus disease in populations of *Pieris* at the time of the finding of one of the previously known gynandromorphs of *P. brassicae* and of two in the related *P. napi*, as well as a sudden occurrence of variation.

The data concerning the outbreak of a major attack of virus and the discovery of a gynandromorph or varietal form is summarised in Table 2.

As can be seen from this table the two recessive varieties *albinensis* and *coerulea* were preceded by virus outbreaks. During the period 1964-67, when the Cambridge stock was free of virus the occasional specimen of these varieties continued to turn up from time to time. Some time after the fresh 1968 virus outbreak however, the percentage of these two varieties appearing rose as high as 5 per cent in some of the weekly batches reared. Also after the outbreak the virus free stock showed a permanent change in the facies of the adults.

SUMMARY

The evidence from large scale breeding has shown that *P. brassicae* gynandromorphs are of two types. The partial or complete bilateral where at least one pair of the wings are

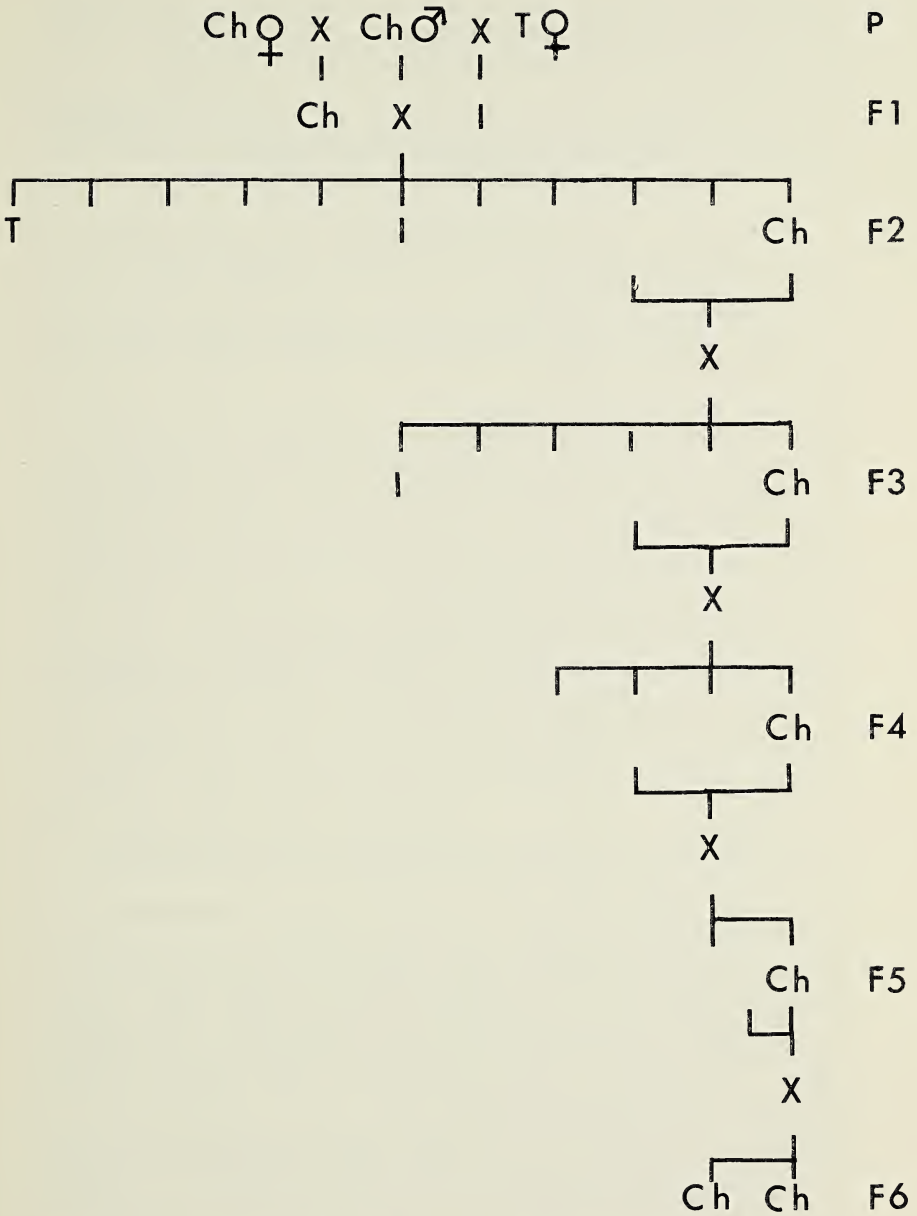


Fig. 11.—The geneology of the *Cheiranthi* stock. Rigid selection of the most Cheiranthi-like individuals was made thro F2 to F6. Ch = cheiranthi; T = typical brassicae; I = intermediate type individual.

completely of one sex; the mosaic type where the sexual mixing is randomly distributed on all four wings. All examples of this type appeared in one brood originating from Hereford.

It is considered that the cause of both gynandromorphism and also of other varietal forms in *P. brassicae* is caused by genetic damage due to the action of granulosis virus.

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TWO NEW SUBSPECIES OF *EUPHYDRYAS CHALCEDONA*

FROM THE MOJAVE DESERT OF SOUTHERN CALIFORNIA

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Euphydryas chalcedona Doubleday (Nymphalidae) reaches its greatest diversity of geographic variation in the southern California region. This checkerspot ranges from the coast through the lower mountain slopes into the mountain ranges of the eastern deserts. In these desert ranges, isolated populations have diverged considerably in phenotype in all stages of the life cycle, and have been studied by lepidopterists since Hovanitz' excellent work in the 1940's and 1950's. The imminent publication of a book (Emmel and Emmel, 1973) on the butterflies of southern California requires the description of two widely recognized but unnamed subspecies endemic to certain of the mountain ranges of the eastern and western Mojave Desert.

***Euphydryas chalcedona kingstonensis*, new subspecies** (Figure 1, a and b)

Diagnosis: This is a *small* subspecies with *tannish brown* ground color. The forewings above are usually well marked with black scaling, contrasting sharply with the light tan apical spots. The females are less marked with black on the inner half of the forewings. The hindwings above are light tan in ground color, largely overlaid with rich fulvous brown in the medial portions and black along the proximal anal margin. A double line of black outlines the submarginal row of light tan spots. Ventrally, the forewings of both sexes are quite similar. A double row of creamy arrowhead-shaped spots (five in each row), separated by black scaling, occurs from the apex to the midpoint of the outer forewing edge. Some light tan

to creamy scaling extends along the leading forewing edge to the medially-placed, black-outlined rectangular spot of slightly darker fulvous at the distal end of the cell. More proximally, there is a second black-outlined rectangular spot of slightly darker fulvous within the cell. The remainder of the forewing is concolorous dull tannish brown, with only a touch of faint black scaling at several points along the trailing edge of the forewing on some specimens. The undersurface of the hindwing in both sexes is strongly whitish cream in overall aspect, with a submarginal row of large, rounded arrowhead-shaped cream spots (edged in black and proximally shaded with a greater amount of black), a medial row of large polygonal cream spots edged with black, and four or more irregularly-shaped cream spots (edged with black) close to the body. The dull tannish brown of the forewings is found around these proximal hindwing spots, the marginal edge of the wing, and as patches on tannish-cream spots lying between the outer and medial rows of large black-outlined cream spots previously mentioned.

The subspecies is named for the type locality, the Kingston Range of the eastern Mojave Desert (Section 3, Township 19 North, Range 10 East). For many years, collectors have taken these brown *Euphydryas* in the Providence Mountains and have often referred to them as *Euphydryas chalcedona hermosa* Wright (1905) for the want of a better name. However, *E. c. hermosa* is a distinctly rich deep *orangish* subspecies, whereas *E. c. kingstonensis* Emmel & Emmel is dull tannish brown. Furthermore, *kingstonensis* tends to be more heavily marked with black scaling on the upperside. The range of *E. c. hermosa* is centered in the lower mountains of Arizona; additional populations are known from northwestern New Mexico, and southern Utah. There are long series of that subspecies in the collection of the Los Angeles County Museum of Natural History from Oak Creek Canyon and Rainbow Trail, Coconino County, Arizona; Paradise, Arizona; Peppersauce Canyon, Santa Catalina Mts., Arizona; Roosevelt Dam, Gila County, Arizona; Chiricahua Mts., Cochise County, Arizona; Fort Wingate, New Mexico; Stockton and Eureka, Utah.

The foodplant of *Euphydryas chalcedona kingstonensis* is the bush penstemon, *Penstemon antirrhinoides* Benth. ssp. *microphyllum* (Gray) Keck (Scrophulariaceae).

HOLOTYPE Male: Radius of forewing, 19.5 mm; CALIFORNIA, San Bernardino County, rocky canyon 3/4 air mile SE of Horse Thief Springs, 4400-4800', Kingston Range. [Lo-

cality No.] #134b. Larva collected March 29, 1969. Emerged: IV-14-1969 (John F. Emmel & Oakley Shields).

ALLOTYPE Female: Radius of forewing, 23.0 mm; same locality data and collectors as holotype. Larva collected March 29, 1969. Emerged: IV-17-1969.

PARATYPES: 24 specimens as follows: same data as holotype, ex larvae, with emergence dates from IV-13 to IV-20, 1969: 11 males, 13 females.

The holotype and allotype will be deposited in the collection of the Los Angeles County Museum of Natural History. Paratypes will be placed in the collections of the following institutions: Los Angeles County Museum of Natural History, Allyn Museum of Entomology, United States National Museum, and the Lepidoptera Research Foundation.

In addition to the type material, we have examined several hundred specimens of wild-caught and reared adults from Bonanza King Mine Canyon and other localities in the Providence Mountains, and from the Granite Mountains north of Amboy, San Bernardino County. Adults of these populations are slightly less heavily marked with black dorsally, but are assignable to the name *kingstonensis*.

Euphydryas chalcedona corralensis, new subspecies

(Figure 1, c and d)

Diagnosis: This is a generally small subspecies with a ground color of *dull orangish red*, even coral red on fresh individuals. The forewings above have yellowish cream spots extending from the basal to submarginal areas, in four wavy vertical rows (less well defined proximally). The two distal, submarginal rows of yellowish cream spots are well outlined with black scaling, more extensive in the female and extending to the proximal (basal) yellowish cream spots in that sex. The hindwings above are almost uniformly dull orangish red in about half the adults, the remainder having several partial to occasionally nearly complete submarginal and basal rows of cream colored spots extending forward from the rear margin. The posterior basal portion of the hindwing is washed with black scaling. Ventrally, the wings of both sexes are similar in general aspect and have the same dull coral ground color. A double row of yellowish cream apical spots (four to five), separated by black scaling, occurs from the apex to almost the

midpoint of the outer forewing edge. Several separate light yellowish cream median spots occur below the inner spot row. The usual two black-outlined spots in and at the end of the forewing cell are weakly present and irregular in outline; the inner portions of these spots are coral. The undersurface of the hindwing presents a strikingly uniform alternation of two rows (marginal and medial) of coral spots, starting at the margin, and two rows of large yellowish cream spots (submarginal and submedial), with a mixture of coral and yellowish cream spots of irregular shape in the basal portion.

The subspecies is named for the type locality, Rock Corral at the south end of Johnson Valley at the base of the foothills (locally known as the Bighorn Mountains) of the northeastern end of the San Bernardino Mountains, in the southwestern Mojave Desert (Section 27, Township 3 North, Range 4 East). Collectors who have taken this reddish checkerspot here in past years have often referred to it erroneously as *Euphydryas chalcedona quino* Behr (1863), a quite different butterfly named from the western Colorado Desert in San Diego County. A full discussion of the taxonomic confusion surrounding the latter insect is given elsewhere (Emmel & Emmel, 1973).

The foodplant of *Euphydryas chalcedona corralensis* Emmel & Emmel is *Penstemon antirrhinoides* ssp. *microphyllum*.

HOLOTYPE Male: Radius of forewing, 21.0 mm.; CALIFORNIA, San Bernardino County, Rock Corral, III-22-1965, leg. T. C. Emmel & J. F. Emmel.

ALLOTYPE Female: Radius of forewing, 24.0 mm.; same locality as holotype, with data label as "Rock Corral, S. Bernardino C., 10 Mar. 1936, female Coll. by [Bred] C. M. Dammers" (brackets ours).

PARATYPES: 65 specimens as follows: same data as holotype, 5 males; same data as allotype except collected as larvae (no date given) and emergence dates as follows for 26 males (5 March to 14 April 1936) and 32 females (15 March to 20 April 1936); Rattlesnake Canyon, 1 male, 24 March 1935, and 1 female, 29 March 1935, C. M. Dammers [San Bernardino County, seven miles to the west of Rock Corral].

The holotype and allotype will be deposited in the collection of the Los Angeles County Museum of Natural History. Paratypes will be placed in the collections of the following institutions: Los Angeles County Museum of Natural History, Allyn Museum of Entomology, United States National Museum and the Lepidoptera Research Foundation.



Fig. 1.—Two new subspecies of *Euphydryas chalcedona* from the Mojave Desert: *E. chalcedona kingstonensis* Emmel & Emmel (upper left, holotype male; upper right, allotype female) from the Kingston Range, and *E. chalcedona corralensis* Emmel & Emmel (lower left, holotype male; lower right, allotype female) from Rock Corral.

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BUTTERFLIES OF MIDDLE AND SOUTHERN BAJA CALIFORNIA

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INTRODUCTION

SOUTHERN CALIFORNIA SURELY REPRESENTS ONE of the areas of the world most thoroughly investigated for butterflies. In contrast, a scant handful of collectors seem ever to have ventured south into the wilds of Baja. For this reason while I lived in Pasadena, California, in 1969 and 1970, I decided to look in that direction rather than facing the awesome competition of Southern California Lepidopterists in their native habitat.

The following list summarizes the records I made during this period. Little collecting was done north of the Valle de Trinidad, which crosses the entire peninsula of Baja at an altitude below 3200' about 100 miles south of the U.S. border. This valley is very arid except on the western edge. To the north of Valle de Trinidad, the Sierra Juarez rises to 5000' or 6000' more or less continuously all the way from San Diego County. To the south, the Sierra San Pedro Martir form a vast plateau (Figure 1), with extensive area between 8000' and 9500'. Consequently, if any line of demarcation could be defined between true Baja fauna and "blend region" with San Diego County, it would logically lie here.

All localities mentioned in this article may be located on the map, Figure 2. In the list, species with records from south of Valle de Trinidad previously published by Rindge [1948] are indicated by an "R." Records published from this portion of Baja California Norte by Powell [1958] are cited by "P(BCN)," and records specifically established by Patterson and Powell [1959] from the San Pedro Martir are cited by "P(SPM)."



Figure 1. Northern edge of the Sierra San Pedro Martir plateau as seen from west, above Meling Ranch. Photograph is taken around 3500', and top of plateau, about 8500', is 15 miles distant. The road serves the Observatorio Astronomico Nacional, operated by Mexican National University.

The Cary-Carnegie Expedition species of HesperIIDae reported by Miller [1970] are marked with "CC." MacNeill's [1962] species are denoted with an "M." Finally, Megathymidae records in Freeman's work [1968] are referred to by an "F." The following additional abbreviations are used in my list: BC = Baja California (state), BCS = Baja California Sur (territory), and SPM = Sierra San Pedro Martir.

Species numbers and names are as given by dos Passos [1964], except where since revised: *Philotes*, Langston [1969]; Melitaeinae, dos Passos [1969]; Theclinae, dos Passos [1970]; and Megathymidae, Freeman [1968].

It is really not within my aim here to give a detailed travelogue of the incidents and adventures which transpired during my visits to Baja. However, the prospective Baja traveler may find the following remarks informative: Most of the roads we passed required a vehicle with compound low gear, a skid plate to protect the oil pan, and high clearance. We were equipped with four-wheel drive (used very rarely except during a torrential rain in March 1970) an extra-heavy duty mechanical winch (used only to help others), and gasoline capacity for 400 miles. A good toolbox and a tire repair kit were found to be much more helpful than a second spare tire, as flat tires invariably occurred in odd numbers (i.e., 1, 3, or 5). The Automobile Club of Southern California guidebooks [1970, 1971] offer invaluable automotive advice to the Baja motorist. In traversing over 5000 miles of Baja dirt road, we never experienced a serious difficulty. Figure 3 shows a typical rural Baja road in normal state, and Figure 4 shows conditions during the flooding of March 1970. The rural Baja ranchers are overwhelmingly friendly when one leaves the beaten trails, especially if one knows even 100 words or so of Spanish. We spent many nights at some rancher's home with sleeping bags in front of a fireplace on a dirt floor or cot. The only real taboo in rural Baja is to pass someone in distress without offering assistance. I would especially like to mention the hospitality and friendliness of the remote and prosperous village of El Rosario, and the constant companionship of Carol Spence whose attraction for the frontier and the Old West led far indeed from the Los Angeles freeways.

In the future, Baja California collecting by others in the Sierra Victoria, the Sierra San Borja, and the Sierra San Pedro Martir would seem to me most intriguing. The Sierra Victoria are well watered, definitely subtropical, and very isolated from the Mexican Mainland tropics. April and October would likely be the best months; that is, when seasons change and both wet and dry season material might be on the wing. The Sierra San



Figure 2. Baja California and adjacent Mexican mainland. The Sierra Juarez extends from Valle de Trinidad to the U. S. border, the Sierra San Pedro Martir from Valle de Trinidad to El Metate, the Sierra San Borja from Bahia de Los Angeles to the boundary of Baja California Sur, and the Sierra Victoria from San Pedro to Cabo San Lucas. Guadalupe Island is about 200 miles WSW of El Rosario in the Pacific Ocean.

Borja rise above 5000', and, because of its extreme isolation, seem never to have been visited by a Lepidopterist. When flying over, waterholes and local areas of very green vegetation may be seen, though. The San Pedro Martir Range has been fairly well explored from September to early June. As far as I know, though, July-August material, which summer rains might bring out, is totally unsampled.

LIST OF SPECIES

MEGATHYMIDAE

Agathymus comstocki (Harbison); 13-IX-70, Meling Ranch-Mike's Sky Ranch Rd. Jct., BC, 700'; F.

Agathymus dawsoni Harbison; 20-IX-70, 5 Mi. S. of Punta Prieta, BC; F.

10. *Agathymus stephensi* (Skinner); F.

HESPERIIDAE

Hesperiinae

23. *Panoquina panoquinoides errans* (Skinner); R; P(BCN); CC; M.
 27. *Calpodus ethlius* (Stoll); 27-IX-70, La Paz, BCS; P(BCN); CC.
 29. *Lerodea eufala* (Edwards); 27-IX-70, 8 Mi. S. of San Pedro, Mex. 11, BCS, 1000'; 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; 13-IX-70, El Rosario, BC; 22-IX-70, San Ignacio, BCS, 900'; R; CC; M.
 30. *Lerodea arabus* (Edwards); R; CC [as *dysaules* Godman]; M [as *dysaules*].
 39. *Amblyscirtes tolteca* Scudder; 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; 29-IX-70, 30 Mi. S. of Todos Santos, BCS; R; CC.
 71. *Paratrytone melane* (Edwards); R; M.
 79. *Ochlodes sylvanoides* (Boisduval); P(BCN).
 80. *Ochlodes agricola* (Boisduval); 21-IV-70, 12 Mi. W. of Meling Ranch, SPM, BC, 1000'; 19-IV-70, 20 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'; P(BCN); M.
 87. *Atalopedes campestris* (Boisduval); 18-X-69, 12-IX-70, Meling Ranch, SPM, BC, 2000'; CC; M.
 91. *Polites sabuleti* (Boisduval); 18-X-69, Meling Ranch, SPM, BC, 2000'; 13-IX-70, 25-IV-70, El Rosario, BC; R; P(BCN); CC; M [as *margarettae* Miller and MacNeill].
 98. *Polites sonora* (Scudder); P(SPM).
 108. *Hesperia pahaska williamsi* Lindsey; P(SPM).
 122. *Hylephila phyleus* (Drury); 18-X-69, Meling Ranch, SPM, BC, 2000'; 27-IX-70, La Paz, BCS; 22-IX-70, San Ignacio, BCS, 900'; 24-IX-70, Mulege, BCS; R; CC; M.
 125. *Copaodes aurantiaca* (Hewiston); 27-IX-70, 10 Mi. S. of San Antonio, Mex. 11, BCS, 1500'; 19-IX-70, Bahia de Los Angeles, BC; 17-IX-70, Rancho El Metate, SPM, BC, 2000'; 22-IX-70, 4 Mi. E. of San Ignacio, BCS, 1100'; 22-IV-70, 20 Mi. W. of Rancho Rosarito, SPM, BC, 1900'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; R; CC; M.
 139. *Nastra neamathla* (Skinner & Williams); CC.
Vorates decorus (Herrich-Schaeffer); R [doubtful, see M].
 Pyrginae
 148. *Pholisora catullus* (Fabricus); 27-IX-70, 2 Mi. N of San Pedro, BCS, 500'; 24-IX-70, Mulege, BCS; 22-IX-70, 4 Mi. E. of San Ignacio, BCS, 1100'; 29-IX-70, 8 Mi. N. of Cabo San Lucas, BCS; 19-IX-70, Bahia de Los Angeles, BC; P(BCN); M.
 150. *Pholisora libya* (Scudder); 18-IX-70, 70 Mi. N. of Rancho Chapala, BC, 2600'; 23-IX-70, 5 Mi. N. of Santa Rosalia, BCS; R; P(BCN).
 153. *Heliopetes domicella* (Erichson); R; CC; M.



Figure 3. A typical rural Baja California road. This track extends 50 miles from El Rosario to El Metate. The tall oddly-shaped plants are cirios (*Idria columnaris*). It is said perhaps the scenery here comes closest to an armchair traveler's picture of Baja—gentle hills, a green cast of cirio and cardon, and the quiet whisper of a primeval wilderness.

154. *Heliopetes ericetorum* (Boisduval); 19-IX-70, Bahia de Los Angeles, BC; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 4-III-70, 20 Mi. E. of El Rosario, SPM, BC, 800'; P(BCN).
155. *Heliopetes laviana* (Hewiston); R; CC; M.
160. *Pyrgus scriptura* (Boisduval); 24-IV-70, Rancho El Metate, SPM, BC, 2000'; P(SPM).
161. *Pyrgus communis* (Grote); 18-X-69, 12-IX-70, Meling Ranch, SPM, BC, 2000'; 13-IX-70, El Rosario, BC; 22-IX-70, San Ignacio, BCS, 900'; 22-IV-70, 20 Mi. W. of Rancho Rosarito, SPM, BC, 1900'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 30-V-70, Valledares, SPM, BC, 2500'; 4-III-70, 20 Mi. E. of El Rosario, SPM, BC, 800'; 7-II-70, K-90, Mex. 5, BC; 23-IV-70, Rancho Rosarito, SPM, BC; 25-IV-70 Rancho El Metate, SPM, BC, 2000'; R; P(BCN); CC; M.
162. *Pyrgus oileus philetas* Edwards; 27-IX-70, 8 Mi. S. of San Pedro, Mex. 11, BCS, 1000'; R; CC; M.
164. *Erynnis brizo lacustra* (Wright); P(SPM).
166. *Erynnis afraanius* (Lintner); P(SPM).
168. *Erynnis funeralis* (Scudder and Burgess); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 27-IX-70, La Paz, BCS; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 8-II-70, 5 Mi. N. of Puertecitos, BC; 7-II-70, San Felipe, BC; 18-IV-70, 19 Mi. W. of Mike's Sky Ranch, SPM, BC, 3800'; 23-IV-70, Rancho Rosarito, SPM, BC, 2500'; 25-IV-70, 17-IX-70, Rancho El Metate, SPM, BC, 2000'; R; P(BCN); CC.
170. *Erynnis pacuvius callidus* (Grinnell); 20-V-69, Teacup Spr., SPM, BC, 8000'; 30-V-70, Valledares, SPM, BC, 2500'; 31-V-70, Santa Cruz, SPM, BC, 3200'; P(SPM).
172. *Erynnis tristis pattersoni* Burns; CC.
175. *Erynnis propertius* (Scudder and Burgess); 20-V-69, Teacup Spr., SPM, BC, 8000'; 24-V-69, W. of Corona Meadow, SPM, BC, 7000'; P(BCN).
178. *Chiomara asychis pelagica* (Weeks); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 19-IX-70, Bahia de Los Angeles, BC; 24-IX-70, Mulege, BCS; 22-IX-70, San Ignacio, BCS, 900'; R; CC; M.
182. *Systasea pulverulenta* (Felder); R [doubtful, see M].
183. *Systasea evansi* (Bell); 22-IX-70, 4 Mi. E. of San Ignacio, BCS, 1100'; 22-IV-70, 20 Mi. W. of Rancho Rosarito, SPM, BC, 1900'; 21-IV-70, 12 Mi. W. of Meling Ranch, SPM, BC, 1000'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 1-III-70, 16 Mi. S. of Puertecitos, BC; 23-IV-70, Rancho Rosarito, SPM, BC, 2500'; 27-IX-70, 8 Mi. S. of San Pedro, Mex. 11, BCS, 1000'; P(BCN); CC; M.
187. *Staphylus ceos* (Edwards); P(SPM); CC.
193. *Cogia hippalus peninsularis* Miller and MacNeill; 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; CC; M.
201. *Thorybes pylades* (Scudder); 20-V-69, Teacup Spr., SPM, BC, 8000'; 19-V-69, Jierba Buena, SPM, BC, 8000'; 24-V-69, W. of Corona Meadow, SPM, BC, 7000'; 31-V-70, Santa Cruz, SPM, BC, 3200'; P(SPM).
206. *Thorybes valeriana* (Plötz); CC.
217. *Urbanus proteus* (Linnaeus); R; CC; M.
218. *Urbanus dorantes* (Stoll); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 27-IX-70, La Paz, BCS; 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; 29-IX-70, 7 Mi. E. of Cabo San Lucas, BCS; R; CC; M.
225. *Codatractus arizonensis* (Skinner); R [as *cyda* (Godman and Salvin), see M].
231. *Chiodides albofasciatus* (Hewiston); 28-IX-70, San Jose del Cabo, BCS; R; CC; M.
236. *Epargyreus clarus* (Cramer); P(SPM).



Figure 4. The main Peninsular Highway at Rancho Chapala during the torrential flooding of March 1970. Rain had not fallen here for the previous two years, and did not fall again for at least a year more. The nearby dry lakebed of Laguna Seca Chapala was overnight transformed from two miles of choking dust into a little ocean, complete with whitecaps.

PAPILIONIDAE

246. *Battus philenor* (Linnaeus); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 28-IX-70, San Jose del Cabo, BCS; R.
248. *Papilio polyxenes* Fabricius; 27-IX-70, La Paz, BCS; 22-IX-70, 4 Mi. E. of San Ignacio, BCS, 1100'; R.
252. *Papilio zelicaon* Lucas; 19-IV-70, 20 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'.
256. *Papilio cresphontes* Cramer; 27-IX-70, La Paz, BCS; 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; R.
263. *Papilio rutulus* Lucas; 12-IX-70, 22-IV-70, Meling Ranch, SPM, BC, 2000'; 29-V-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 30-V-70, Santa Cruz, SPM, BC, 3200'; P(BCN).
265. *Papilio eurymedon* Lucas; 19-V-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 19-IV-70, 20 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; P(BCN).

PIERIDAE

275. *Pieris beckerii* Edwards; 26-XII-69, El Porvenir, El Rosario, BC; 13-IX-70, El Rosario, BC; 3-III-70, 10 Mi. S. of Rancho Santa Ynez, BC, 2100'; 24-IV-70, 17 Mi. NE of El Rosario, SPM, BC, 1100'; R; P(BCN).
276. *Pieris sisymbrii* Boisduval; 20-IV-70, 12 Mi. E. of Meling Ranch, SPM, BC, 4600'; 19-IV-70, Mike's Sky Ranch, SPM, BC, 3800'; R; P(BCN).
277. *Pieris protodice* Boisduval and Le Conte; 26-XII-69, El Porvenir, El Rosario, BC; 25-IV-70, Rancho El Metate, SPM, BC, 2000'; 18-X-69, K-210, Mex. 1, BC, 400'; 18-X-69, Meling Ranch, SPM, BC, 2000'; 27-IX-70, La Paz, BCS; 8-II-70, 5 Mi. N. of Puertecitos, BC; 24-IX-70, Mulege, BCS; 30-V-70, Valledares, SPM, BC, 2500'; 25-IV-70, El Rosario, BC; 22-IV-70, 20 Mi. W. of Rancho Rosarito, SPM, BC, 2100'; 7-II-70, 28-II-70, San Felipe, BC, 7-II-70, K-90, Mex. 5, BC; R.
280. *Pieris rapae* (Linnaeus); 18-X-69, K-210, Mex. 1, BC, 400'; 25-XII-69, Camalu, BC; 12-IX-70, Meling Ranch, SPM, BC, 2000'; 31-V-70, Santa Cruz, SPM, BC, 3200'; P(BCN).
281. *Ascia monuste* (Linnaeus); 19-IX-70, Bahia de Los Angeles, BC; 27-IX-70, La Paz, BCS; 24-IX-70, Mulege, BCS; 21-IX-70, 35 Mi. N. of San Ignacio, BCS, 800'; R.
Ascia sevata kuschei (Schaus); R.
286. *Colias eurytheme* Boisduval; 23-V-69, Corona Meadow, SPM, 8000'; 24-IV-70, 17 Mi. NE of El Rosario, BC, 1100'; 31-V-70, Santa Cruz, SPM, BC, 3200'; 7-II-70, San Felipe, BC; 8-II-70, 17 Mi. N. of Puertecitos, BC; 1-III-70, 8-II-70, 9 Mi. S. of Puertecitos, BC; 26-IX-70, K-175, Mex. 1, BCS; 26-IX-70, K-220, Mex. 1, BCS; 30-V-70, Valledares, SPM, BC, 2000'; 3-III-70, 10 Mi. S. of Rancho Santa Ynez, BC, 2100'; P(BCN).
289. *Colias harfordii* H. Edwards; 12-IX-70, Corona Meadow, SPM, BC, 8000'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; 29-V-70, 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 23-IV-70, Rancho San Miguel, Rancho Rosarito, SPM, BC, 2900'; 19-IV-70, Mike's Sky Ranch, SPM, BC, 3800'; P(SPM).
298. *Colias eurydice* Boisduval; 30-V-70, Valledares, SPM, BCS, 2500'; 20-IV-70, 12 Mi. E. of Meling Ranch, SPM, BC, 4600'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; P(BCN).
299. *Colias caesona* (Stoll); 17-IX-70, Rancho El Metate, SPM, BC, 2000'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; 1-III-70, 9 Mi. S. of Puertecitos, BC; R.

300. *Anteos clorinde* (Godart); 27-IX-70, 8 Mi. S. of San Pedro, Mex. 11, BCS, 1000'; R.
301. *Anteos maerula* (Fabricius); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; R.
302. *Phoebis senna eubule* (Linnaeus); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 17-IX-70, Rancho El Metate, SPM, BC, 2000'; 21-IX-70, 13 Mi. N. of San Ignacio, BCS, 1000'; R.
305. *Phoebis agarithe* (Boisduval); 19-IX-70, Bahia de Los Angeles, BC; 23-IX-70, 5 Mi. N. of Santa Rosalia, BCS; 21-IX-70, 13 Mi. N. of San Ignacio, BCS, 1000'; R.
310. *Eurema दौरа* (Godart); 29-IX-70, 7 Mi. E. of Cabo San Lucas, BCS; R.
311. *Eurema boisduvaliana* Felder and Felder; 27-IX-70, 8 Mi. S. of San Pedro, Mex. 11, BCS, 1000'; R.
312. *Eurema mexicana* (Boisduval); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; R.
314. *Eurema proterpia* (Fabricius); 27-IX-70, 8 Mi. S. of San Pedro, Mex. 11, BCS, 1000'; R [as *gundlachia* (Poey)].
315. *Eurema lisa* Boisduval and Le Conte; 27-IX-70, 8 Mi. S. of San Pedro, Mex. 11, BCS, 1000'; 25-IX-70, Airstrip at S. end of Bahia Concepcion, BCS; 24-IX-70, Mulege, BCS; R.
316. *Eurema nise* (Cramer); 27-IX-70, 8 Mi. S. of San Pedro, Mex. 11, BCS, 1000'; R.
319. *Eurema nicippe* (Cramer); 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; R.
Eurema jacunda (Boisduval and Le Conte); R.
320. *Nathalis iole* Boisduval; 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 30-V-70, Valledares, SPM, BC, 2000'; 23-IV-70, Rancho Rosarito, SPM, BC, 2500'; R; P(BCN).
321. *Anthocharis cethura deserti* Wright; R; P(BCN).
324. *Anthocharis sara* Lucas; 22-IV-70, 14 Mi. W. of Rancho Rosarito, SPM, BC, 5300'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 3-III-70, 10 Mi. S. of Rancho Santa Ynez, BC, 2100'; 4-III-70, 20 Mi. E. of El Rosarito, BC, 800'; 23-IV-70, Rancho San Miguel, Rancho Rosarito, SPM, BC, 2900'; 23-IV-70, 11 Mi. W. of Rancho Rosarito, SPM, BC, 2300'; R; P(BCN).
326. *Anthocharis lanceolata australis* (Grinnell); 24-V-69, W. of Corona Meadow, SPM, 7000'; 20-IV-70, 12 Mi. E. of Meling Ranch, SPM, BC, 4600'; 19-IV-70, Mike's Sky Ranch, SPM, BC, 3800'; P(BCN).
328. *Euchloe ausonides* (Lucas); P(BCN).

RIODINIDAE

334. *Apodemia mormo maxima* (Weeks); 24-IX-70, Mulege, BCS; R.
334. *Apodemia mormo dialeuca* Opler and Powell, 24-V-69, W. of Corona Meadow, SPM, BC, 7000'; 22-IV-70, Rancho El Cipres, SPM, BC, 1800'; 20-IV-70, 6 Mi. E. of Meling Ranch, SPM, BC, 2800'; 19-IV-70, Meling Ranch, SPM, BC, 2000'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 19-IV-70, 20 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'; 4-III-70, 20 Mi. E. of El Rosarito, SPM, BC, 800'; 3-III-70, 10 Mi. S. of Rancho Santa Ynez, BC, 2100'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; 23-IV-70, Rancho Rosarito, SPM, BC, 2500'; P(BCN) [as *virgulti* (Behr)].
335. *Apodemia palmerii* (Edwards); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; 19-IX-70, Bahia de Los Angeles, BC; 29-IX-70, 20 Mi. N. of Cabo San Lucas, BCS; R.
344. *Lephelisca nemesis* (Edwards); R; P(BCN).

346. *Lephelisca wrighti* (Holland); 29-V-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 30-V-70, Valledares, SPM, BC, 2500'; 21-IV-70, 12 Mi. W. of Meling Ranch, SPM, BC, 1000'; 4-III-70, 20 Mi. E. of El Rosario, BC, 800'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; 8-II-70, 5 Mi. N. of Puertecitos, BC.
Melanis acroleuca (Felder); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; R.

LYCAENIDAE

Theclinae

351. *Chlorostymon simaethis* (Drury); R.
 360. *Satyrium saepium* (Boisduval); P(BCN).
 374. *Ministrymon leda* (Edwards); 19-IX-70, Bahia de Los Angeles, BC; 18-IX-70, Rancho Santa Ynez, BC, 2000'; 17-IX-70, Rancho El Metate, SPM, BC, 2000'; 18-IX-70, 6 Mi. W. of Mission Calamjue, BC, 1800'; 27-IX-70, La Paz, BCS; 22-IX-70, San Ignacio, BCS, 900'; R.
 386. *Incisalia iroides* (Boisduval); 24-V-69, W. of Corona Meadow, SPM, BC, 7000'; 22-IV-70, 2 Mi. W. of Rancho El Cipres, SPM, BC, 1800'; 20-IV-70, 14 Mi. E. of Meling Ranch, SPM, BC, 5300'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; P(BCN).
 392. *Mitoura loki* (Skinner); P(BCN).
 395. *Mitoura spinetorum* (Hewiston); P(SPM).
 397. *Mitoura nelsoni* (Boisduval); P(BCN).
 401. *Callophrys dumetorum perplexa* Barnes and Benjamin; 20-IV-70, 12 Mi. E. of Meling Ranch, SPM, BC, 4600'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; 18-IV-70, 19 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'.
 408. *Atlides halesus* (Cramer); 18-IX-70, 17 Mi. N. of Rancho Chapala, BC, 2600'; 17-IX-70, Rancho El Metate, SPM, BC, 2000'; R; P(BCN).
 413. *Hypostrymon critola festata* (Weeks); 27-IX-70, La Paz, BCS; 29-IX-70, 20 Mi. N. of Cabo San Lucas, BCS; R.
 417. *Strymon melinus* Hübner; 18-IX-70, 17 Mi. N. of Rancho Chapala, BC, 2600'; 13-IX-70, 25-IV-70, El Rosario, BC; 1-III-70, 8-II-70, Puertecitos, BC; 1-III-70, 16 Mi. S. of Puertecitos, BC; 18-IV-70, 19 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'; R.
 422. *Strymon columella* (Fabricius); 1-III-70, 16 Mi. S. of Puertecitos, BC; R; P(BCN).

Lycaeninae

431. *Lycaena gorgon* (Boisduval); P(SPM).
 435. *Lycaena xanthoides* (Boisduval); R.

Plebejinae

446. *Brephidium exilis* (Boisduval); 18-X-69, Meling Ranch, SPM, BC, 2000'; 26-IX-70, K-200, Mex. 1, BCS; 22-IX-70, 4 Mi. E. of San Ignacio, BCS, 1100'; 22-IV-70, Rancho El Cipres, SPM, BC, 1800'; 4-III-70, Los Coronados Is., BC; 8-II-70, Puertecitos, BC; 1-III-70, 16 Mi. S. of Puertecitos, BC; 2-III-70, Mission Calamajue, BC, 3-III-70, 10 Mi. S. of Rancho Santa Ynez, BC, 2100'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; 25-IV-70, Rancho El Metate, SPM, BC, 2000'; R.
 448. *Leptotes cassius striata* (Edwards); [as marina, see PCBCN].
 449. *Leptotes marina* (Reakirt); 24-V-69, Corona Meadow, SPM, BC, 7000'; 26-XII-69, El Porvenir, El Rosario, BC; 29-IX-70, 20 Mi. N. of Cabo San Lucas, BCS; 29-V-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 1-III-70, Puertecitos, BC; 8-II-70, 17 Mi. N. of Puertecitos, BC; 1-III-70, 16 Mi. S. of Puertecitos, BC; 25-IV-70, Rancho El Metate, SPM, BC, 2000'; R; P(BCN).

452. *Hemiargus ceraunus*; 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 29-IX-70, 8 Mi. N. of Cabo San Lucas, BCS; 26-IX-70, Mex. 1, K-175, BCS; 26-IX-70, Mex. 1, K-220, BCS; 30-V-70, Valledares, SPM, BC 2000'; 1-III-70, 8-II-70, Puertecitos, BC; 7-II-70, San Felipe, BC; 1-III-70, 16 Mi. S. of Puertecitos, BC; 25-IV-70, Rancho El Metate, SPM, BC, 2000'; R; P(BCN).
453. *Hemiargus isol*a (Reakirt); P(BCN).
458. *Plebejus icarioides evius* (Boisduval); 24-V-69, W. of Corona Meadow, SPM, BC, 7000'; 19-V-69, Jierba Buena, SPM, BC, 8000'; P(SPM).
462. *Plebejus acmon* (Westwood and Hewiston); 19-IV-70, Mike's Sky Ranch, SPM, BC, 3800'; 23-IV-70, Rancho Rosarito, SPM, BC, 2500'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 20-IV-70, 12 Mi. E. of Meling Ranch, SPM, BC, 4600'; many additional SPM records; P(BCN).
470. *Everes amyntula* (Boisduval); 23-V-69, Corona Meadow, SPM, BC, 8000'; 29-V-70, 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 4-III-70, El Consuelo, BC; 19-IV-70, Mike's Sky Ranch, SPM, BC, 3800'; R; P(BCN).
471. *Philotes battoides bernardino* Barnes and McDunnough; 22-IV-70, 20 Mi. W. of Rancho Rosarito, SPM, BC, 1900'; 19-IV-70, 20 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'; 23-IV-70, Rancho Rosarito, SPM, BC, 2500'; many additional SPM records; R.
477. *Philotes sonorensis* (Felder and Felder); 22-IV-70, 27 Mi. W. of Rancho Rosarito, SPM, BC, 2000'; 20-IV-70, 14 Mi. E. of Meling Ranch, SPM, BC, 5300'; 3-III-70, 10 Mi. S. of Rancho Santa Ynez, BC, 2100'; 19-IV-70, Mike's Sky Ranch, SPM, BC, 3800'; P(BCN).
479. *Glaucopsyche lygdamus australis* Grinnell; 29-V-70, 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 20-IV-70, 12 Mi. E. of Meling Ranch, SPM, BC, 4600'; 4-III-70, 20 Mi. E. of El Rosario, SPM, BC, 800'; 3-III-70, 10 Mi. S. of Rancho Santa Ynez, BC, 2100'; 19-IV-70, Mike's Sky Ranch, SPM, BC, 3800'; P(SPM).
481. *Celastrina argiolus echo* (Edwards); 24-V-69, W. of Corona Meadow, SPM, BC, 7000'; 20-IV-70, 14 Mi. E. of Meling Ranch, SPM, BC, 5300'; R.

LIBYTHEIDAE

482. *Libytheana bachmanii* (Kirtland); 19-IX-70, Bahia de Los Angeles, BC; 23-IX-70, 5 Mi. N. of Santa Rosalia, BCS; R.

NYMPHALIDAE

486. *Anaea aidea* (Guérin); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 25-IX-70, Airstrip at S. end of Bahia Concepcion, BCS; 24-IX-70, Mulege, BCS; R.
502. *Mestra amymone* (Ménétriés); R.
510. *Myscelia skinneri* Mengel; 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; 24-IX-70, Airstrip at S. end of Bahia Concepcion, BCS; 24-IX-70, Mulege, BCS; R [as *streckeri* (Skinner)].
520. *Limenitis lorquini* (Boisduval); 12-IX-70, Meling Ranch, SPM, BC, 2000'; P(BCN).
522. *Limenitis bredowii californica* (Butler); 30-V-70, 2 Mi. E. of Valledares, SPM, BC, 2500'; 29-V-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'.
525. *Anartia jatrophae* (Johansson); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; R.
527. *Vanessa atalanta* (Linnaeus); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS; 18-IV-70, 19 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'.

529. *Cynthia cardui* (Linnaeus); 25-XII-69, Camalu, BC; 14-III-70, Los Coronados Is., BC; 7-II-70, San Felipe, BC; R.
530. *Cynthia annabella* Field; 19-X-69, Meling Ranch, SPM, BC, 2000'.
531. *Precis coenia* (Hübner); 19-X-69, 12-IX-70, Meling Ranch, SPM, BC, 2000'; 30-V-70, Valladares, SPM, BC, 2000'; R; P(SPM).
551. *Chlosyne gabbii* (Behr); P(SPM).
562. *Chlosyne californica* (Wright); 22-IX-70, 4 Mi. E. of San Ignacio, BCS, 1100'; 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; R.
563. *Phyciodes texana* (Edwards); 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; R.
574. *Thessalia leanira* (Felder and Felder); 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'; 20-IV-70, 6 Mi. E. of Meling Ranch, SPM, BC, 2800'; 29-V-70, 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 19-IV-70, 20 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'.
579. *Dymasia chara* (Edwards); 27-IX-70, 10 Mi. S. of San Antonio, Mex. 11, BCS, 1500'; 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; 29-IX-70, 20 Mi. N. of Cabo San Lucas, BCS; 22-IX-70, 4 Mi. E. of San Ignacio, BCS, 1100'; 21-IX-70, 13 Mi. N. of San Ignacio, BCS, 1000'; 22-IV-70, 20 Mi. W. of Rancho Rosarito, SPM, BC, 1900'; 29-IX-70, 8 Mi. N. of Cabo San Lucas, BCS.
593. *Euphydryas chalcedona* (Doubleday); 20-IV-70, 6 Mi. E. of Meling Ranch, SPM, BC, 2800'; 29-V-70, 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'; 22-IV-70, 28 Mi. E. of Rancho Rosarito, SPM, BC, 2000'; 19-IV-70, 20 Mi. W. of Mike's Sky Ranch, SPM, BC, 1800'; 31-V-70, 5 Mi. W. of Santa Cruz, SPM, BC, 3000'.
593. *Euphydryas chalcedona quino* (Behr); 19-IV-70, 9 Mi. W. of Mike's Sky Ranch, SPM, BC, 2800'.
624. *Euptoieta claudia* (Cramer); 23-IX-70, 10 Mi. S. of Santa Rosalia, BCS.
625. *Euptoieta hegesia* (Cramer); 28-IX-70, 12 Mi. NW of San Jose del Cabo, BCS, 800'; 27-IX-70, 2 Mi. N. of San Pedro, Mex. 11, BCS, 500'; 24-IX-70, Mulege, BCS; 21-IX-70, 13 Mi. N. of San Ignacio, BCS, 1000'; R.

HELICONIIDAE

630. *Agraulis vanillae* (Linnaeus); 28-II-70, San Felipe, BC, 8-II-70, Puertecitos, BC; R.

DANAIDAE

633. *Danaus gilippus strigosus* (Bates); 30-V-70, Valladares, SPM, BC, 2000'; 8-II-70, Puertecitos, BC; 7-II-70, K-90, Mex. 5, BC; 1-III-70, 16 Mi. S. of Puertecitos, BC; R.

SATYRIDAE

658. *Cercyonis silvestris* (Edwards); P(BCN).

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VITAL STAINING AS EVIDENCE FOR WING CIRCULATION IN THE CABBAGE BUTTERFLY *PIERIS RAPAE*

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INTRODUCTION

A BRIEF REVIEW OF THE LITERATURE on wing circulation is necessary to introduce the present work.

1. *Hemolymph in the Wing*. — The question of wing circulation obviously presupposes the presence of hemolymph, on which point there may be popular misconception. Lutz (1935), in his well-known "Field Book of Insects", asserted that "Wing 'veins' or 'nerves' neither contain blood nor have anything to do with the nervous system". In fact, innumerable studies report the presence of hemolymph in the veins of insect wings, simply because this observation is made easily by crushing or cutting the veins under a low-power microscope.

2. *Wing Circulation in Insects in General*. — According to Yeager and Hendrickson (1934), wing circulation was reported for a grasshopper in 1744 and up to 1934 had been claimed for 50 species representing 10 orders. The Lepidoptera in this list are *Smerinthus populi* and *Sphinx convovulvi*. Circulation in the cockroach wing is easily observed and has been the subject of a number of studies, e.g. by Yeager and Hendrickson (1934) and Clare and Tauber (1942). General accounts of insect physiology by Beard (1953) and Wigglesworth (1965) conclude that wing circulation probably is universal. However, wing circulation is far from clearly established in Lepidoptera.

3. *Wing Circulation in Lepidoptera*. — Reports range from denial of circulation to the assumption that it exists as part of respiration by the wing. Zeller (1938) claimed that there is no circulation in the adult wing of the meal moth *Ephestia kühni*-

ella. Holland (1931) left open the possibility of circulation by saying, "The wings consist of a framework of horny tubes which are in reality double, the inner tube being filled with air, the outer tube with blood. . . . After emergence, the circulation of blood in the outer tube is largely, if not altogether, suspended". Assuming circulation, Packard (1880) stated that "the aeration of the blood is carried on in the wings, and thus they serve the double purpose of lungs and organs of flight". This resembles the conclusion (Portier, 1932a, Portier and Emmanuel, 1932) that blood and air circulation proceed in the wings and that the sunlight "acts as a motor" by creating temperature differentials. Another suggestion by Portier (1932b) is that the seemingly hollow scales and peduncles of *Parnassius* wings are permeable to gases and communicate with tracheal capillaries.

Clare (1965) studied various Lepidoptera and in no case was able to detect an active general circulation, although evidence suggested that circulation occurs at least in recently-eclosed adults. Clare concluded that in the Lepidoptera "the problem of wing circulation is far from satisfactorily understood" and "remains in an unsatisfactory state of affairs". Further references to Clare's work will be made in the discussion.

EXPERIMENTAL

1. *Dye Feeding Procedure*. — Adults of *Pieris rapae* (L.) were fed an aqueous solution of 10% sucrose and 1% neutral red, this dye being chosen because of its efficacy in vital staining of *P. rapae* when fed to larvae (Kolyer, 1965). An 11.2% sucrose solution was used for feeding *Pieris brassicae* by David and Gardiner (1961), and insects have been observed to accept sugar solutions containing neutral red or other dyes (Stober, 1927).

The feeding procedure was that recommended by Urquhart (1960) for *Danaus plexippus*. That is, a small piece of cotton wool was placed in a watchglass and saturated with the solution, and the butterfly was placed on this with wings held together over the back between thumb and forefinger. In this procedure, the tarsi touch the sugar solution, which contact is claimed to stimulate feeding in *Pieris* (work of Minnich as cited by Wigglesworth, 1965), although Verlaine (1927) concluded that *P. rapae* tastes with the tongue rather than the tarsi, and Anderson (1932) found questionable discrimination of sugar by the legs of *P. rapae*.

At the end of feeding, to avoid damaging the legs, which tend to catch in the fibers, a pencil point was offered the insect so that it voluntarily climbed off the cotton. The butterflies were kept in a dark box between feedings to minimize wing damage by flight.

In order to conserve dye while always having fresh (less than one week old) sucrose solution, separate solutions in deionized water were prepared. These were 2.0 wt.-% neutral red (Matheson Coleman & Bell Div., Matheson Co., 88% total dye content), shaken occasionally and allowed to stand for several days to ensure complete dissolution of the dye, and 20 wt.-% sucrose. Before each feeding, equal volumes of the solutions (5 drops each) were mixed in a watchglass before adding just enough cotton to absorb most of the liquid.

2. Dye Feeding Experiments. — In the first experiment, five females, eclosed approximately 10 hours before, were given their first feeding by the above method. The proboscis was not extended voluntarily but had to be uncoiled with a pin and forced into the solution, where it then was kept voluntarily for under 2 minutes. At the end of two days, on the 5th feeding, the proboscis was extended voluntarily by two individuals and was kept in the solution for up to 2.5 minutes. Pink color was apparent in the wing veins, especially near the body. At the end of 4 days, on the 10th feeding, the butterflies could be left sitting on the cotton without restraining the wings, and the longest feeding time was 10 minutes.

At 5.5 days, four of the females were placed in a cage with two unstained males (38-48 hours old) and exposed to sunlight for about 10 hours. Thirteen eggs, ranging from pale to deep pink, were found on cabbage leaves which had been hung up in the cage. The females were fed again (13.5 minutes maximum feeding time), and the males were fed 10% sucrose solution without neutral red. Exposure to sunlight for two more days yielded 13 more pink eggs. All the eggs collapsed and shriveled within three days. Dissection indicated that the pink color was concentrated in the shell, which contained turbid, pale-yellow liquid.

At this point two of the females died. Examination under 16X showed red proboscis, eyes approximately normal green (which turned to rich brown-red within two days after death vs. brown for unstained specimens), interior of abdomen purplish red, and interior of thorax orange.

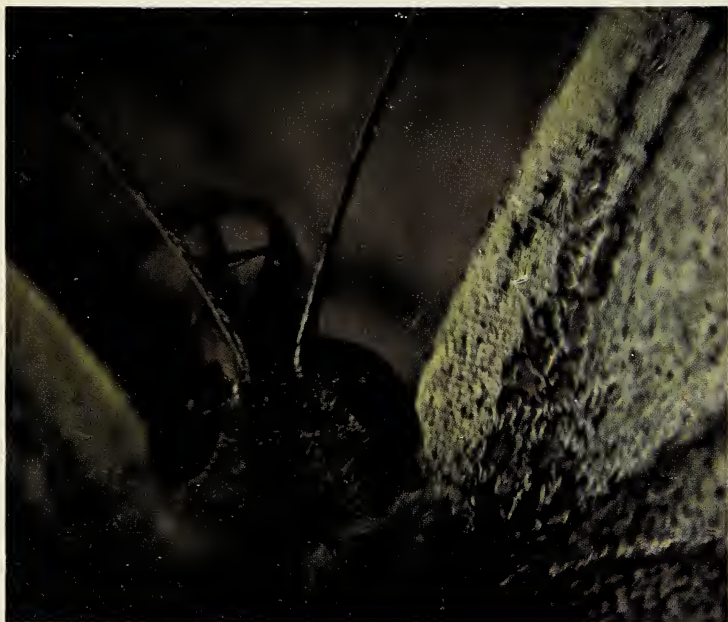


Fig. 1. Specimen of *Pieris rapae* (♀) showing vital staining of the wing veins by feeding neutral red and sucrose solution for 10 days (details in text).

Fig. 2. Specimen of *P. rapae* (♂) fed neutral red and sucrose solution for 8 days (details in text). The photograph was taken through a 16X microscope.



Fig. 3. End view of a section of a hindwing from a specimen of *P. rapae* (♀) whose body, with ventral portion of thorax amputated, had been immersed for one hour in 2% neutral red solution. The photograph was taken through a 100X microscope.

Fig. 4. Apex of a forewing from a specimen of *P. rapae* (♂) which had been immersed in neutral red solution (in the manner described for Fig. 3) for 15 minutes. The photograph was taken through a 16X microscope.

The remaining two females were fed three more times. On the final feeding (10 days from the start of the experiment) both extended the proboscis voluntarily and drank the solution for 25 and 33 minutes. After two more days both seemed near death (movements were feeble) and were killed and spread. One specimen is shown in Figure 1.

In the second experiment, the wings of two males, eclosed about 20 hours before, were mutilated on the righthand side; in one the margins of both fore- and hindwings were trimmed off, and in the other the apex of the forewing was removed. A third (undamaged) male also was included. These were fed 14 times in 8 days, at the end of which time, still capable of vigorous flight, they were killed and spread. As with the females, feeding time tended to increase with age (maximum 17 minutes, at 5 days), and the proboscis often was extended voluntarily. Again, pink color appeared in the veins, and the eyes turned rich brown-red after death (see Figure 2). The antenna clubs were pink to red.

During the feeding experiments, room conditions were 71-78°F and 32-38% relative humidity.

3. *Injection of Dye.* — A capillary was used, in the manner of Campbell (1932), to inject approx. 1.7 milligrams of 2% neutral red solution into the thorax through the dorsal surface of four individuals 25-35 hours old. The liquid was forced in by lung power, via a rubber tube attached to the capillary. Puncturing the integument of many insects results in no hemorrhage (Beard, 1953), and this was true in the present case.

Red color appeared in the annular channels of the veins. In a somewhat similar experiment, Muenchberg (1966) injected $\text{Na}_2\text{S}^{35}\text{O}_4$ into dragonflies to gain evidence for wing circulation. In the present work no additional attention was paid injection because vital staining gave the same effect.

4. *Dissection Methods.* — In one procedure, the lower part of the thorax, including the legs, of a living butterfly was clipped off with small scissors just before immersing the underside of the body in 2% neutral red solution. Rapid movement of the dye into the veins was noted (see Results and Discussion). Similar dye movement was noted by the alternate procedure of severing a wing in the basal region and inserting the cut edge in the dye solution, but this method was not so convenient as the first.

5. *Technique for Observing Hemolymph in Veins.* — To observe liquid in the veins, the lefthand wings were clipped off at

the base, and the body was fastened with transparent tape to a microslide so that the righthand wings were lying flat. Hemolymph (violet to pink for the vitally-stained veins) was observed easily at 16X by rubbing away the scales and running the edge of a needle point along the vein to collapse it and concentrate a drop of liquid inside the trachea. For closer observation, Permount mounting medium (Fisher Scientific Co.) was dropped on the slide under the wing and then on top of the wing, and a cover glass was added. Due to refractive index similarity, the veins in the living wing then could be observed by transmitted light at 100 or 430X.

6. *Experiment on Respiration by Wings.* — In an incidental experiment, the wings of a living butterfly were cut off about a third of the way from the base and were inserted through a slot in a rubber sheet covering a jar with a little carbon tetrachloride in the bottom. After two hours the insect was struggling actively, suggesting that wing tracheae play little, if any, role in general respiration.

RESULTS AND DISCUSSION

1. *Observation of Hemolymph in the Veins.* — With the living wing of a 26-36 hour old male in Permount to give transparency (see Experimental) the hemolymph was observed easily by transmitted light (substage illuminator), but hemocytes seemed essentially absent. By intensive study at 430X, a few small particles were believed to have been seen (but motes in the eye can create this illusion) in the veins in the discal area of the forewing moving toward the margin at 0.7-1.3 mm/min. Tauber and Snipes (1936) report an average velocity of 34 mm/min., with 10 mm/min. as the lowest velocity, for hemocytes in the elytron of the cockroach.

Application of pressure to the thorax caused many colorless bodies to appear, apparently by dislodgment from the walls of the channels. Clare (1965) reported such dislodgment of "fatty-like tissue cells" when the amputated wings of Lepidoptera were pressed between microslides. These bodies could be seen "rounding the bend" at the extremities of the veins into the marginal channel. Relief of the pressure allowed the bodies to drift back toward the base of the wing.

These observations show that hemolymph existed throughout the vein system of a 26-36 hour old butterfly and that this hemo-

lymph communicated with the thorax, but circulation was not detected.

2. *Vital Staining Results.* — The red color of the dye appeared in all the veins of the dye-fed specimens to within a few millimeters of the margin (see Figure 1). Even when the margins of both wings, or the apex of the forewing, had been amputated before feeding, the veins were stained to within 4 mm or less of the edge. In one female (not that shown in Fig. 1), sections of the marginal channel were well-stained in both fore- and hindwings. This result clearly demonstrates that hemolymph can exist essentially throughout the vein system of well-fed adults and that this hemolymph communicates with the hemolymph of the body, but the question of circulation must be considered carefully.

It might be proposed that the hemolymph in the wings remains stagnant and the dye molecules diffuse into it. Such diffusion was ruled out for the dissection results (see below) and is believed to be unacceptable as the explanation for vital staining of the veins, but another problem remains. Admitting that flow of dyed hemolymph into the veins is necessary to account for staining, there are two alternatives: (1) there is a return flow of hemolymph to the body (true circulation) or (2) evaporation of water from the veins and wing membrane causes fresh hemolymph to flow out from the thorax *without* a return flow (*not* true circulation). Of course, the real situation may be complex, e.g. true circulation may occur in young adults with outward flow predominating in older individuals.

3. *Dissection Results; Evidence of "Water Deficit" in Veins.* — The technique of removing the lower part of the thorax and immersing in dye solution (see Experimental) was used with wild adults of unknown age. The red solution appeared in the veins in one minute and reached the margin, in some cases, within 10 minutes. Some random observations of distance attained (from base of hindwing) vs. time are: 8 mm in 7 min., 15 mm in 5 min., and 17 mm in 9 min. For a forewing, an observation was 12 mm in 11 min. Similar movement into the channels occurred when a wing section was inserted in the dye solution.

These rates (up to 3 mm/min.) must be explained by capillary action and/or suction rather than diffusion of dye molecules into stagnant hemolymph. As evidence, a glass capillary tube, approx. 0.2 mm inside diameter, was filled with clear, green

hemolymph from the thorax of a living adult, and 2% neutral red solution was added to one end so that it contacted the hemolymph. The color front had advanced into the hemolymph a total of about 1 mm after 9 min., 2 mm after 23 min., and 3 mm after 43 min. In the much-smaller channel of the vein this advance would be, if anything, slower because of even less opportunity for convection currents to provide mixing.

The dye solution moved within the channel (annulus) of the vein, not the lumen (trachea), as shown by cross-sectioning under the microscope. Figure 3 shows an example. This is an end view of a wing section, not a microtomed slice, so that the light-red color visible in the lumen is the result of light shining through the deep-red wall-channel.

The dye solution followed various courses, seemingly random, in filling the channels of some of the veins but not others. Using the venation scheme illustrated by Klots (1951), in both hindwings from the same adult the dye solution ran out into veins R and Cu_2 *only*. In one wing the dye ran a short distance down the marginal channel from the end of R ; in the other wing the dye ran up the margin from Cu_2 and back *into* M_3 a short distance. This tendency of dye solution to travel along the margin and then run back into a vein was noted in other cases. For example, in a forewing the dye ran out the 2nd A vein only, up the margin, and back into Cu_2 a short distance. Another example is shown in Figure 4, where the dye can be seen to have run back into R_3 .

Results for wings from the same adult were sometimes dissimilar. For example, in one forewing the dye followed both upper and lower veins bounding the discal cell, in the other forewing only the lower vein. In another case, the dye appeared in approximately 80% of the total venation of one forewing vs. approximately 10% of the other. In one hindwing, an estimated 95% of the total venation was colored, with "breaks" in the middle of veins where dye fronts had been moving in opposing directions.

To further demonstrate that a deficit of liquid in the channels was causing the dye solution to run along the veins, the thorax of a male, taken outdoors, was cut as usual, and the underside of the body was immersed in water. After one hour, the insect was transferred to 2% neutral red solution, and after another hour the wings were removed and examined. There was no red color in the veins, even in the basal area, indicating that water had filled the channels.

The water deficit would be expected to be less in recently-eclosed individuals, and this was found to be true. By the usual technique (thorax cut), a 10 hour old male (not fed), after one hour in the dye solution, showed red in only one forewing (in one vein, out to 4 mm) and one hindwing (out to 2 mm in the basal veins). Similarly, a 21 hour old male (not fed) showed no red in the forewing veins and red to 4 mm in a vein on one hindwing.

CONCLUSION

Two mechanisms, which both may play a role, must be considered in attempting to explain the vital staining results: (1) the hemolymph circulates to and from the body, or (2) evaporation from the wing surface creates a gradual flow of hemolymph from the body into the vein-channels with *no* return flow.

Two observations favor the latter hypothesis:

(1) Removal of the marginal channel before dye-feeding did not prevent the red color from appearing close to the ends of the veins. According to Clare (1965), "When this (marginal) channel is broken much of the circulation may be arrested", as would be expected if the hemolymph must flow out to the margin through one vein and back to the body through another. Assuming that hemolymph cannot move from one vein to another within the two-layered wing membrane, the only way to explain a close approach of dyed hemolymph to the ends of severed, "dead-end" veins is by one-way flow or the supposition of an efferent channel *and* an afferent (return) channel within the same vein, a possibility for which there was no evidence.

(2) A "water deficit" in the vein-channels of older adults was demonstrated. The random paths followed by the dye solution in making up this deficit did not suggest that hemolymph normally flows outward in certain veins and back through others, as in the cockroach wing. In fact, the presence of a deficit in the majority of the veins; as noted in many cases, would seem to preclude active circulation whether the deficit be caused by (a) empty space in the annular channels or (b) expansion of the tracheae against the walls of the veins to close the channels. Clare (1965) states "Some aged adults may contain little or no hemolymph in the wing channels, but this study suggests that this is probably exceptional." Further, "If hemolymph (moisture) gets low in the body, perhaps some of the channels become air-filled."

The present work indicates that a moisture or hemolymph deficiency begins within one day from eclosion for unfed specimens and certainly is common among *P. rapae* in the field. A possibility is that in the vitally-stained individuals the supply of water in the body was ample so that dyed hemolymph flowed outward from the thorax, as required by evaporation, to keep the vein-channels filled and the wing, as described by Clare (1965), in a "moist and lifelike condition".

Among the questions raised by the results are: Can the water deficit be only temporary and disappear, i.e. channels become refilled, after a butterfly feeds? How long can a deficit of water in most of the channels be tolerated before the wing becomes overly desiccated? Does true circulation exist at least in new adults before the deficit becomes widespread. Information might be secured by ageing and intermittently feeding a sizeable number of individuals which had eclosed at about the same time and by taking statistically-significant samples to follow the extent of the water deficit by the dissection technique described above.

In short, vital staining seems to demonstrate efferent flow of hemolymph but does not prove the afferent flow required for true circulation. Efferent flow alone, without return of hemolymph to the body, explains the data.

SUMMARY

Beginning 10-20 hours from eclosion, adults of *Pieris rapae* (L.) were fed (for 8-10 days) an aqueous solution of 1% neutral red (an effective vital stain) and 10% sucrose. The annular hemolymph channels of the wing veins, including parts of the marginal channel, were found to contain pink (dyed) hemolymph. This result demonstrates efferent flow but leaves in question the afferent (return) flow required for true circulation. Amputation of the lower part of the thorax of living adults (taken outdoors) and insertion of the body of 2% neutral red solution caused flow (up to 3 mm/min.) of the dye solution into the vein-channels, often including the marginal channel and staining from about 10% to 95% of the total venation. This effect was slight (veins colored only in basal region) in 10 or 21 hour old individuals and was prevented entirely by placing the body in water for a time, allowing water to fill the channels, before transferring to the dye solution. The "water deficit"

presumably is created by evaporation and may involve empty (air-filled) channels and/or channels closed by expansion of tracheae. It is suggested that efferent flow alone, without true circulation, may explain the vital staining of the veins. In support of this, removal of the marginal hemolymph channels before dye-feeding would be expected to suppress true circulation (Clare, 1965), but severed, "dead-end" veins were found to be stained to within a few millimeters of their ends.

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A DWARF FORM OF *EUPTOIETA CLAUDIA* (NYMPHALIDAE)

Russell A. Rahn

DURING A COLLECTING VACATION in August, 1970, this writer chanced to capture several specimens of *Euptoieta claudia* (Cramer). After spreading the catch, the interesting gradation shown in the accompanying photograph was noted. The photograph shows a wingspan range from $1\frac{3}{8}$ " to 2." Brown (1965) has indicated that a series of miniature *E. hegesia* can be found in the American Museum, and that the dwarf form of this species was taken in the Santa Rita Mountains of southeastern Arizona. The specimens of *E. claudia* figured here were captured in the Dakotas, between August 18 and 21. The largest specimen at the top was "captured" on the radiator of the automobile somewhere in western North Dakota, while the remaining specimens were taken at the Outlaw Ranch, near Custer, Custer County, South Dakota.

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BUTTERFLY RECORDS FOR THREE NORTHWEST WISCONSIN COUNTIES

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A recent book (Ebner, 1970) on butterflies of Wisconsin is almost devoid of records or other information regarding the northwest portions of the state. During the past five seasons, I have conducted quite a bit of field collecting in 18 Wisconsin counties. Very little of this was general collecting, but in most cases I had a specific objective such as documenting the range of *Erebia discoidalis* (see Masters, 1971) or collecting bog species. At least 75% of my collecting efforts were expended in Burnett, Rusk and St. Croix counties and I have accumulated enough data from these counties to provide preliminary lists of their lepidopterous faunas. Hesperids have been collected to a very limited extent and are excluded from this treatise.

BURNETT COUNTY

BURNETT COUNTY IS PRIMARILY TRANSITION ZONE forest including extensive areas of seral birch-aspen associations, and smaller areas of basswood-maple-oak association and some red or jack pine forests. Most of my collecting has been done in the jack pine forests just to the east of Danbury. This area has been very productive in producing *Incisalia* species (see Masters, 1970), *Euchloe olympia* and *Hesperia metea* Scudder (Hesperiidae) during late May and I have also collected it extensively during late June searching, thus far in vain, for *Oeneis macounii* (Edwards). Forty-four species are recorded for Burnett County and another nine are considered as possible. There is also a possibility that *Pieris virginiensis* and *Polygonia satyrus* are to be found here in maple forests and *Chlosyne harrisii* in marshy areas. The total list for Burnett County should reach 60 species. Ebner (1970) had very few records in Wisconsin for several species that are fairly abundant in Burnett County, these include: *Phyciodes batesii*, *Incisalia polios*, *Incisalia henrici* and *Incisalia augustinus*.

Table one. Butterfly records for Burnett, Rusk and St. Croix counties, Wisconsin: Papilionidae, Pieridae, Danaidae, and Libytheidae.

SPECIES	BURNETT COUNTY	RUSK COUNTY	ST. CROIX COUNTY
<i>Papilio polyxenes asterius</i> St.	Upr	A-ds; 6.7	A-ws; 7.8.9.10
<i>Papilio glaucus canadensis</i> R.&J.	SII-wc; 6.7	SII-wa; 6.7	Uu
<i>Papilio glaucus glaucus</i> L.	Up	Uu	SIII-wc; 6.7.8
<i>Pieris protodice protodice</i> B.&LC.	Upr	P,A-dr; 5	P,A-ds; 5.6.8
<i>Pieris napi oleracea</i> Harris	SII-ds; 5.6.7.8	SII-dc; 5.6.7.8	Uu
<i>Pieris rapae rapae</i> L.	A-wc; 5-9	A-wc; 5-9	A-wa; 5-10
<i>Colias eurytheme eurytheme</i> Bois.	A-wa; 6-9	A-wa; 6-9	A-wa; 6-10
<i>Colias philodice philodice</i> Gdt.	A-wa; 5-9	A-wa; 6-9	A-wa;
<i>Colias interior interior</i> Scud.	SII-ls; 7	SII/B-dc; 7	Uu
<i>Nathalis iole</i> Bois.	Poly-mr; 8	Up	Poly-mc; 8.9.10
<i>Euchloe olympia anntha</i> dp.&Kts.	SII-da; 5.6	SII-dr; 6	SII-dc; 5.6
<i>Danaus pterippus</i> L.	Poly-mc; 6-9	Poly-mc; 6-9	Poly-mc; 6-10
<i>Lethe anthedon borealis</i> Clark	Up	SII-dc; 6.7	Uu
<i>Lethe anthedon anthedon</i> Clark	SIII-ls; 7	Up	SIII-wc; 6.7
<i>Euptychia cymela cymela</i> Cram.	SIII-ls; 6	Up	SIII-wa; 6
<i>Lethe eurydice eurydice</i> Joh.	PIII-lr; 7	PIII-lc; 7.8	PIII-lc; 7
<i>Coenonympha tullia inornata</i> Edw.	PII-lr; 7	Up	Uu
<i>Cercyonis pegala nephele</i> Kby.	A-wc; 7.8	A-wc; 7.8	A-wc; 7.8
<i>Oeneis jutta ascerta</i> M.&S.	Up	BII-lc; 6	Uu
<i>Libythea bachmanii bachmanii</i> Kirt.	Up	Up	Poly-mr; 8

RUSK COUNTY

The forests of Rusk County are of Transition Zone character, but are more boreal appearing than those of Burnett County. There are also numerous sphagnum bogs in Rusk County and it is these that have received most of my attention in collecting. Rusk County bogs have yielded good numbers of *Oeneis jutta*, *Boloria eunomia*, *Incisalia augustinus* and *Lycaena epixanthe*. *Erebia discoidalis*, *Boloria freija* and *Boloria frigga*, are also bog inhabiting species that should occur in Rusk County. The Blue Hills region, to the west of highway 40 between Bruce and Exeland, provides excellent upland forest collecting areas. The banks of the Chippewa and Thornapple Rivers turned out to be excellent collecting areas for *Feniseca tarquinius* during the summer of 1971. They were fairly abundant, on several occasions, on small trees and shrubs (especially American Hazel *Corylus americana* Walt.) right on the rivers' banks, but were absent on similar vegetation 20-30 feet back from the rivers.

I have recorded 50 species for Rusk County and three more are indicated as probable. In addition, *Pieris virginiensis*, *Lycaeides argyrognomon*, *Polygonia satyrus* and *Chlosyne harisii* are likely here. The total county list should total at least 65.

ST. CROIX COUNTY

Although I reside in St. Croix County, I have never undertaken intensive collecting here. Quite a few of my records are from butterflies that my children or neighbor children have collected in North Hudson, other records (of easily distinguishable species) are of sight observations.

In St. Croix County, the dominant hardwood forests are typical of the Upper Austral Zone; these forests are broken by marshes and agricultural areas. In North Hudson there is quite a bit of land that has been turned back from agricultural usage but which has not yet been converted to houses. This "vacant lot" habitat is very well suited for a number of species including: *Papilio polyxenes*, *Nymphalis antiopa*, *Nymphalis milberti*, *Polygonia comma*, *Polygonia interrogationis*, *Nathalis iole* and *Cercyonis pegala*. Other choice species that have been taken in my "back yard" include *Euchloe olympia*, *Incisalia henrici* and the "hybrid" *Limenitis arthemis/astyanax*. Other collecting in the county has been in the lowland marshy areas along the lower Kinnickinnic River at River Falls and along

Table two. Butterfly records for Burnett, Rusk and St. Croix counties,
Wisconsin: Nymphalidae in part.

SPECIES	BURNETT COUNTY	RUSK COUNTY	ST. CROIX COUNTY
<i>Asterocampa celtis</i> B.&LC.	Up	SIII-ds; 7.8	Up
<i>Limenitis arthemis arthemis</i> Dry.	SII-wa; 6.7	SII-wa; 6.7	SIII-wa; 6.7.8
<i>Limenitis arthemis astyanax</i> Fab.	Up	Up	SIII-ws; 6.7.8
<i>Limenitis archippus archippus</i> Cr.	PIII-ds; 8	PIII-ds; 6.8	PIII-ds; 6.7.8
<i>Vanessa atalanta rubria</i> Fruh.	S-ws; 8	S-ws; 7.8	S/A-ws; 5.7.8.9
<i>Cynthia virginensis</i> Dry.	Poly-wc; 8	Poly-wc; 6.7.8	Poly-wc; 5.6.9
<i>Cynthia cardui</i> L.	Poly-mc; 5	Poly-mc; 6.8	Poly-mc; 5.6.8
<i>Junonia coenia coenia</i> Hbn.	Up	Poly-mr; 6	Up
<i>Nymphalis j-album j-album</i> B.&LC.	SII-dr; 5	SII-dr; 8	Up
<i>Nymphalis milberti milberti</i> Gdt.	PIII-dc; 8	PIII-dc; 7.8	A/P-wc; 7.8.9.10
<i>Nymphalis antiopa antiopa</i> L.	SII-ds; 8	SII-dc; 7.8	A/SII-wc; 5-9
<i>Polygonia interrogationis</i> Fabr.	S-ds; 7	S/A-ds; 6.7.8	S/A-wc; 5.7.8
<i>Polygonia comma</i> Harris	S-ds; 7.8	S-ds; 5.7.8	S/A-wc; 5.7.8
<i>Polygonia faunus faunus</i> Edw.	Up	SII/SI-ds; 5.7.8	Uu
<i>Polygonia progne</i> Cr.	S-wc; 5.7.8	S-wc; 5.7.8.9	S/A-dc; 5.7.8
<i>Chlosyne nycteis nycteis</i> Dby.	S/PIII-lc; 6	S/PIII-lc; 6	PII-dc; 6
<i>Phyciodes tharos tharos</i> Dry.	Poly-wa; 5-9	Poly-wa; 5-9	Poly-wa; 5-9
<i>Phyciodes batesi</i> Rkt.	SII/PIII-dc; 7	SII/PIII-ds; 7	Up
<i>Euphydryas phaeton borealis</i> C.&C.	Up	PIII-ls; 6.7	Up
<i>Boloria selene atrocatalis</i> Hd.	B/PIII-da; 6.8	B/PIII-da; 5.6.8	Up

Table three. Butterfly records for Burnett, Rusk and St. Croix counties, Wisconsin: remaining Nymphalidae and Lycaenidae in part.

SPECIES	BURNETT COUNTY	RUSK COUNTY	ST. CROIX COUNTY
<i>Boloria selene</i> nr. <i>myrina</i> Cr.	Up	Up	PIII-la; 5.6.7.8.9
<i>Boloria bellona</i> nr. <i>toddi</i> Holl.	PII-dc; 5.6.8	PII-dc; 5.6.8.9	Up
<i>Boloria bellona bellona</i> Fabr.	Up	Up	PII-dc; 5.6.7.8.9
<i>Boloria eunomia dawsoni</i> B.&McD.	Up	BI-ls; 6	Uu
<i>Speyeria atlantis atlantis</i> Edw.	S/P-wa; 6.7.8	S/P-wa; 6.7.8	Up
<i>Speyeria cybele krautwurmi</i> Hol.	Up	PII-ds; 7	Uu
<i>Speyeria cybele cybele</i> Fabr.	PII-ds; 7	PII-ds; 7	PII-wc; 6.7.8
<i>Speyeria aphrodite aphrodite</i> Fab.	PII-dr; 7	PII-ds; 7	PII/PIII-dc; 7.8
<i>Speyeria aphrodite alceestis</i> Edw.	Up	Uu	PII-ds; 7.8
<i>Euptoieta claudia claudia</i> Crm.	Upr	Upr	A-ms; 6.9
<i>Harknessia titus titus</i> Fabr.	PII-dc; 8	PII-dc; 7.8	PII-dc; 7.8
<i>Satyrus calanus falacer</i> Gdt.	SIIL-ds; 7	Up	SIIL-dc; 7
<i>Satyrus acedica acedica</i> Edw.	Upr	PIII-lc; 7	Upr
<i>Callophrys</i> (Inc.) <i>polios</i> C.&W.	SI/SII-ls; 5	Up	Uu
<i>Callophrys</i> (Inc.) <i>h. henrici</i> G.&R.	S/P-lc; 5	Up	S/P-ls; 5
<i>Callophrys</i> (Inc.) <i>a. augustinus</i> W.	BI; SII-da; 5.6	BI-la; 5.6	Uu
<i>Callophrys</i> (Inc.) <i>niphon clarki</i> F.	SI/SII-lc; 5.6	Upr	Up
<i>Callophrys</i> (Mit.) <i>g. gryneus</i> Hub.	Up	Uu	PII/SIII-ls; 5
<i>Feniseca tarquinius tarquinius</i> F.	Up	SII/*-lc; 6.7.8	Up

*Riverbanks of cold-water rivers such as the Chippewa and Thornapple.

Table four. Butterfly records for Burnett, Rusk and St. Croix counties, Wisconsin: remaining Lycaenidae.

SPECIES	BURNETT COUNTY	RUSK COUNTY	ST. CROIX COUNTY
<i>Lycaena thoe</i> G-M.	Upr	PIII-ls; 8	Upr
<i>Lycaena xanthoides dione</i> Scud.	Upr	Up	PI-dc; 7.8
<i>Lycaena helleoides</i> Bois.	Upr	Up	PII-m?r; 8
<i>Lycaena dorcas dorcas</i> Kby.	Upr	BI/PIII-lc; 6.7	Uu
<i>Lycaena epixanthe</i> (ssp. <i>michiganensis</i> Rawson?)	Up	BI-lc; 7.8	Uu
<i>Lycaena phlaeas americana</i> Har.	PII-ds; 8	Upr	A-wc; 7.8.9
<i>Plebijus saepiolus saepiolus</i> Bois.	SII-dc; 6.7	SII-dc; 6.7	Up
<i>Everes comyntas comyntas</i> Gdt.	Poly-wa; 5-9	Poly-wa; 5-9	Poly-wa; 5-9
<i>Glaucopsyche lygdamus couperi</i> Grt.	SII/P-ds; 5	SII-ds; 5.6	SIII/P-ls; 5
<i>Celastrina argiolus pseudargiolus</i> Bois. & LeC.	SII-dc; 5.6	SII-dc; 5.7.8	SIII-dc; 4.5.7

the Trout Farm Road just east of Hudson, in deciduous forests near Somerset and in pastures south of Houlton where *Mitoura gryneus* is found on Red Cedar.

I have recorded 42 species in St. Croix County, and indicated another five as probable. Additional species to be expected here include two that are not yet known in Wisconsin, *Lethe appalachia* and *Satyrrium caryaevorus*. The county total should be around 58 species.

KEY TO TABLES

For simplicity, to facilitate comparison and to conserve space, I have put the list of species into tabular form (tables 1-4). The annotations on these tables are coded. The first symbol in the code indicates the preferred habitat as noted in that county, the key is as follows:

The last group of symbols is comprised of one or more numbers, these numbers represent the months in which the butterflies have been observed; 1 for January, 2 for February, etc. Where two numbers are separated by a hyphen, e.g. 6-9, this indicates that the species is present throughout the period between the two months indicated.

Poly	—species being well at home in several plant formations.
S	—for silva, forested area.
SI	—coniferous forests exemplifying the Boreal Zone.
SII	—mixed forest areas of Transition Zone character.
SIII	—predominately deciduous forests characteristic of the Austral Zone.
P	—prairie.
PI	—virgin prairie.
PII	—forest glade or savanna meadow.
PIII	—cattail and sedge marsh.
B	—acid bog.
BI	—open muskeg with few or no trees.
BII	—forested bog with moderate to heavy growth of Black Spruce and/or Tamarack.
A	—agricultural area; pastures, cultivated fields or gardens.
Upr	—unrecorded, but of probable occurrence.
Up	—unrecorded, but of possible occurrence.
Uu	—unrecorded and unlikely to occur.

In a few cases, two symbols are used, separated by a / mark. This indicates that the species is most prone to occur where these two habitats meet. Otherwise if two symbols are given, the species is equally at home in both habitats. The second set of symbols, consisting of one capital and one small letter, is an indication of the butterflies abundance.

The key is as follows:

- L —local in occurrence.
- D —discontinuous in occurrence.
- W —widespread in occurrence.
- M —migratory.
- r —rare.
- s —scarce.
- c —not uncommon.
- a —abundant.

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VARIATIONS OF *PARASEMIA PARTHENOS* (ARCTIIDAE)

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FOR FORTY YEARS, I have been gathering Maine material in *Parasemia parthenos* Harris. It occurs in small numbers throughout the more rugged forested portion of the western, northwestern, northern and eastern portions of the State. The species extends north into the subarctic and, though apparently unrecorded, rarely to high elevations in North Carolina. From my own light traps, those operated by friends, and especially about 27 traps for 28 years of the Maine Forestry Department, I have handled many hundreds of *P. parthenos*. A number of specimens may be taken by a light trap one season and then none for a period of years. A selection of these is illustrated on the figure. Harris' type cannot be located, but his illustration of a male specimen (Harris 1950) from north of Lake Superior is much like the upper left hand specimen figured, an average marked specimen. Next below is figured the associated female. The ground color is chocolate brown, varying considerably, especially to a much lighter chocolate brown. It is a species of the opener forest land and arctic-alpine habitats. Some specimen localities can only be given in Maine as a township or the nearest settlement, often some distance away.

P. parthenos parvimaculata new variety. This variety is marked by greatly reduced maculation, and usually a darker chocolate brown ground color. Typical specimens have a short white basal mark, two or three small costal spots and often a preapical small white spot is present. The hindwings inside the orange border are more nearly completely black. This variety seems especially developed in Maine.



Fig. 1

Parasemia parthenos parthenos Harris; Column 1, top, and down; typical ♂, T18R12, Rocky Mountain, Aroostook Co., Me., 15 June; associated ♀, Kokadjo, Piscataquis Co., Me., 19 July; *parthenos* ♀, Clingmans Dome, Swain Co., No. Car., 6200 ft., 18 July 1946; *P. p. parvimaclata* new variety, holotype ♂, Greenville, Me., 29 July; *P. p. parvimaclata*, new var. paratype ♂, St. Francis, Aroostook Co., Me., 19 July.

Column 2, top: *P. p. multimaculata* new variety, holotype ♂, St. Francis, Me., 7 July; *P. p. multimaculata* new var., allotype ♀, Dickey, Aroostook Co., Me., 15 July; *P. p. obsolescens* new aberration ♂, Allagash, Aroostook Co., Me., 16 July; *P. p. parvimaclata* new var., holotype ♂, Dennistown, Somerset Co., Me., 16 July; *P. p. parvimaclata* new var., allotype ♀, Dennistown, Me., 18 July.

Column 3, top: *P. p. borealis* Moesch., typical ♂, Cartwright, Labr., 26 July, 1955, E. E. Sterns; *P. p. borealis* Moesch., ♂, Schefferville, Que., 10 July, 1968, A. E. Brower; *P. p. borealis* Moesch., ♀, Ft. Churchill, Man., 23 July, 1969, A. E. Brower; *P. p. borealis* Moesch., ♂ Mt. Jaques Cartier, 4000 ft., Gaspé, Que., 26 July, 1940 A. E. Brower; *P. p. parthenos* Harris, ♂, St. Francis, Me., 12 July.

Holotype ♂ (The next to last specimen in column 2) St. Francis, Me., 19 July.

Allotype ♀ (The last specimen in column 2) Dennistown, Me., 18 July.

Paratypes 18 males: Oquossoc, 12 July; Dennistown 13 July and 2 Aug.; T8R19, 2 Aug.; T13R12, 8 July; T14R16, 5 and 13 July; T15R9, DeBoulie Mt., 17 July; Allagash, 12 and 18 July and 6 Aug.; St. Francis, 6 Aug.; T18R12, Rocky Mt., two 6 July, 9 July, three 12 July; Kellyland (near Princeton), 12 July. Four females: Dennistown, 18 July; Greenville, 9 Aug.; Long A (near Millinocket), 16 July; Topsfield, 14 July.

P. parthanos multimaculata new variety characterized by an increase over typical, both in number and size of the white spots on the forewings. The t.p. line of spots exhibits this most markedly, and the larger spots are often confluent. The hindwings are variable as is usual.

Holotype ♂, (First specimen in column 2) St. Francis, Me., 12 July.

Allotype ♀ (Second specimen in column 2) Dickey, Me., 5 July.

Paratypes 12 males: T8R19, 8 July; Chesuncook, 16 July; St. Francis, 16 July; T14R16, 10 and 13 July; Allagash, two 12 July; T18R12, 2 July, two 6 July, 12 July, 16 July, Six females: Long A (near Millinocket), 12 July; Pittston Farm (near Seboomook), 11 July; Dennistown, 13 and 16 July; T14R16, 23 July; T18R12 14 July.

P. parthanos obsolescens new aberration, has the whitish creamy spotting enlarged and confluent until the usual pattern is obliterated, all of the forewing being so colored except a basal streak into the cell, a narrow one along the inner margin, a reniform spot, a narrow line of s.t. spots and an irregular broad terminal band. The black on the hindwings is much reduced.

Holotype ♂ Allagash, Me., 16 July.

P. parthanos borealis Moesch. Described from Labrador, this is a well-marked race of the species, characterized by its smaller size (57 mm; *P. p. parthanos* 66 mm), a red-brown color, and a more complete development of the pattern of spots. The black

on the hindwing is reduced on the average. Dr. T. N. Freeman at Ottawa sent me the first specimen in column 3 as typical. The writer has taken *borealis* on the mountains of the Gaspé, Que.; at Schefferville, Que., at the Labrador border, 1700 ft.; and at Churchill and Ft. Churchill, Manitoba. Some specimens from the boundary mountains of Maine and the eastern border of Maine seem intermediate. It is found by day resting in the open tundra or where tree growth is scant.

Type specimens of the varieties *parvimaculata* and *multimaculata* will be placed in the Canadian National Collection, the U. S. National Museum and other collections.

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[Uses the genus *Platyprepia* for *parthenos*.]

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A SEARCH FOR
SPEYERIA NOKOMIS COERULESCENS
(HOLLAND) (NYMPHALIDAE)
IN SOUTHERN ARIZONA

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IN HIS PAPER ON ARIZONA BUTTERFLIES, Dr. Keith S. Brown Jr. (1965) cites the occurrence of *Speyeria nokomis coerulescens* (Holland) in a spring-fed meadow in the upper Huachuca Mountains. The sight record reported therein provided the stimulus that prompted the author to search the Huachucas in an attempt to relocate the meadow, and hopefully, verify the existence of this subspecies in the continental United States. A few vague lines penned by Holland (1931) seemed to reinforce the possibility of a still-viable colony somewhere in that southern Arizona range.

During his five years of intensive field work, from 1967 to 1972, the author has also corresponded extensively with Dr. Brown in an attempt to glean every bit of information concerning the possible location of the meadow and the circumstances surrounding the insect's occurrence. The author is deeply indebted to Dr. Brown for his vivid recollections and unselfish responses to the author's many letters. Though Dr. Brown had been unable to relocate the meadow, himself, on other occasions since the first sighting, he did remember some very important facts which eventually led to the discovery of the meadow by the author in early September of 1971.

Concurrent with the search for the meadow noted by Dr. Brown, the author corresponded extensively with several lepidopterists in order to gain additional information on the habitat and possible flight period of *coerulescens*. This was done in an effort to locate additional suitable sites in the Huachucas where, hopefully, a colony of *coerulescens* might still exist. The author is grateful to Paul Grey, Lincoln, Maine; Dr. Lee

D. Miller, Sarasota, Florida; Lloyd M. Martin, Prescott, Arizona; R. F. Sternitzky, Hereford, Arizona; Kilian Roever, Phoenix, Arizona; F. M. Brown, Colorado Springs, Colorado; Harry Clench, Pittsburgh, Pennsylvania; Fred Thorne, El Cajon, California and Darrel K. Whipple, Park Ranger, Coronado National Memorial, Arizona. Through their letters and personal conversations, these persons rendered invaluable aid to the author and enabled him to properly assess the field conditions under which one may encounter *coerulescens*.

It has definitely been established that members of the genus *Speyeria* utilize various species of *Viola* as the larval foodplants (Mattoon, Davis and Spencer, 1971). In the arid Southwest, the occurrence of violets is almost wholly dependent upon an abundant, unfailing supply of fresh water coupled with mild summers and cold winters. Such suitable conditions in Arizona are rarely found much below 5,000 feet of elevation. Indeed, as an indicator of suitable conditions, the author has never encountered *Speyeria atlantis nausicaa* (Edwards) below that elevation.

In the basin and range province of Arizona, of which the Huachuca Mountains form a part, the chances of finding a colony of *coerulescens* will be dependent upon discovering suitable habitats harboring violets. Permanent water sources are rare in these mountains and abundant precipitation is confined to the higher elevations above 7,000 feet where winter moisture, in the form of snow, may persist through the earlier, drier parts of the year. Thus, along with the search for Dr. Brown's *coerulescens* meadow, the author investigated several potential sites during the months of August through November, 1967 to 1972. The results of these surveys have been negative.

A prime site has been a very wet, spring-fed sedge and horsetail meadow at the top of the box in Ramsey Canyon. In the understory, violets form a lush, dense mat. This site has been visited on several occasions during the months previously noted with no signs of *Speyeria* adults or larvae evident. A reconnaissance of several additional springs made it necessary to hike almost the entire length and breadth of the Huachucas, but did enable the author to secure an intimate, first-hand knowledge of this very interesting range. Practically all of the springs are unsuitable as a *coerulescens* habitat. Most were devoid of violets, or in deep shade, or mere seeps on bare rock or were tapped and the water diverted to a concrete tub or similar container.

Some key clues to the possible location of the meadow at the "top of Sunnyside Canyon" are to be found in two letters from Dr. Brown to the author dated October 26 and November 16, 1969, respectively. He stated that, "The colony was in a wet, very green-grass meadow with a concrete horse watering trough in the middle, already in the pine or fir belt, which is the standard halfway stopping place on the main trail to Miller Peak, probably no more than a couple of hours above where the trail leaves the canyon bottom and heads up the hill." He also stated that, "The area was *definitely* in the pines or firs, an open flat conifer-surrounded and very green area, not more than 100 feet square, *inside* forest."

There is a meadow at the top of Sunnyside Canyon at about 8,400 feet of elevation at the junction of the Miller Peak (Crest) and Sunnyside Canyon Trails. This meadow has been investigated by others, also. It does not contain a horse trough and is quite dry despite the abundance of flowers.

Working with a topographic map of the area (Sunnyside, 1:24,000), the author had suspected the area to the north of Pat Scott Peak, just below the saddle at the top of Pat Scott Canyon in Section 18, T23S, R20E, to be the site of the *coerulescens* sighting some 21 years ago. In following the very obscure trail northward from the main trail junction, the author encountered very little evidence of man's pervious use. Indeed, for the most part, this trail appeared unused and little remained of the trail signs. A broken, barely legible sign indicated this trail to be the Canelo Trail. It presently enters the Military Reservation at the head of Sawmill Canyon but the author did not follow it to its terminus.

There is a meadow at the suspected area which fulfills all of Dr. Brown's vivid recollections and descriptions. Color slides of the area were taken on 1 September 1971 and prints sent to Dr. Brown. He positively identified (in litt.) the meadow from these prints. No *Speyeria* were seen in this meadow on that date, nor were any seen on a subsequent visit a week later.

Workers familiar with *nokomis* subspecies may well question the expectation of finding *coerulescens* in flight on an earlier date. Indeed, the author had repeatedly queried Dr. Brown about his early August sighting. However, the vivid events surrounding the sighting in 1950 were recounted to the author in detail in later letters and, there is very little reason to doubt this insect's occurrence on that early date.

After a wait of one year, the author revisited the Huachucas on 28 July 1972 in the company of his son, Dale. There had been heavy rains in the mountains during the previous weeks, breaking an extended period of drought in that part of Arizona. Our hike up the tortuous Sunnyside Canyon Trail on 29 July was favored with beautiful, clear, sunny skies and the air temperature was not unduly warm. We arrived in the meadow at 9:30 A.M. (M.S.T.) and remained until 11:30 A.M., during which time, in bright sunlight, we investigated the site for adult *Speyeria* and violets. We did not find either. In fact, the spring was not flowing and the meadow was bone-dry. The only water to be found was in the horse trough and it appeared several weeks stagnant. We walked through the meadow a number of times during our stay and followed the run-off channel to the very brink of the canyon, where the flowage cascades over a precipitous cliff. We also waited a short duration at this point hoping for the possibility of seeing wandering males. None were seen.

Over the past twenty years there has been a marked drying trend in the Southwest. Many former permanent water sources have either dried up or are now only seasonal. Also, in some instances, former wet-meadow areas have become invaded by surrounding forest. Such invasions may contribute to the drying trend due to tree roots tapping the moisture source and lowering the water table. Was Dr. Brown's *coerulescens* meadow a victim of such a circumstance? The author is not able to say. There is, however, juvenile growth of pines and spruce now within the upper portion of the meadow, which may not have existed at the time of Dr. Brown's pack trip visit some 21 years ago. We could find no evidence of this meadow having been altered by any human agency in the intervening years.

The question now arises, does *coerulescens* still exist at the meadow? The visible absence of violets and surface water there does not seem to favor such a possibility. Could the adults seen by Dr. Brown have wandered into the meadow from another area, or areas? Such an occurrence is still a possibility even though *nokomis* females are generally not known to stray far from the larval foodplants. There are still many areas in the Huachucas not investigated by the author and there is great hope that, hidden somewhere in a favorable canyon, a colony of *coerulescens* still exists.

Does *coerulescens* still exist as a viable entity somewhere in Arizona? It is hoped that it does. The last known colony,

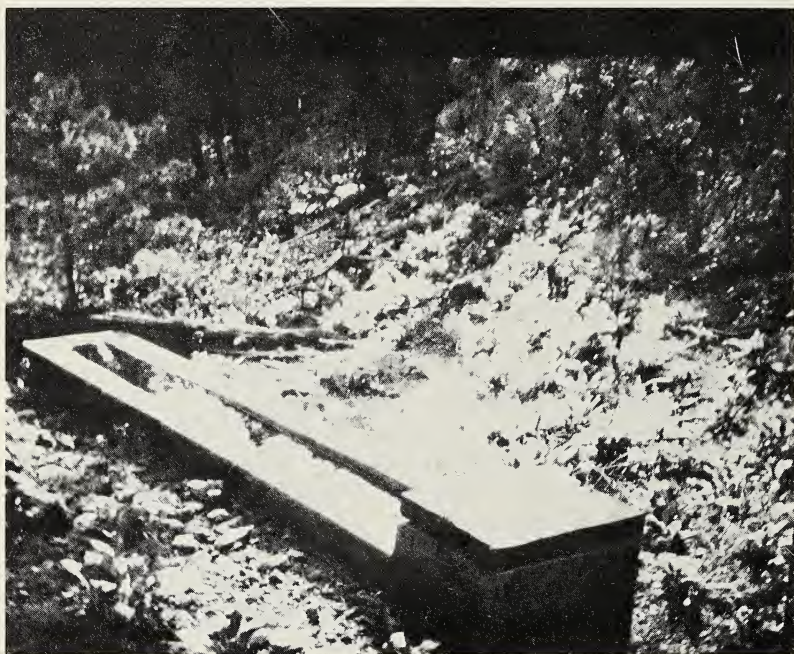


Fig. 2.—Concrete horse trough, *coerulescens* meadow, upper Huachuca Mountains, September 1971



Fig. 3.—Looking northwest toward the spring and the upper end of the *coeruleus* meadow, September 1971.

from which actual specimens have been collected, existed near the top of Mount Lemmon in the Santa Catalinas. The author, as well as others, has visited this site on several occasions with negative results. Also investigated by the author is a meadow on the north slope of Mount Hopkins, very near the summit, in the Santa Ritas. It, too, proved unfavorable.

In later years attention has been focused on the Chiricahua Mountains. There are many suitable areas in this well-watered, extensive range that merit investigation.

Inasmuch as subspecies of *nokomis* are highly cyclical, it will probably take a combination of all of the proper ingredients and a strong dose of luck to rediscover *coerulescens* in Arizona. The author sincerely hopes that some of the information given herein will be of benefit to current and future workers and welcomes an exchange of ideas from interested parties.

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A BILATERAL GYNANDROMORPH
OF *LIMENITIS WEIDEMEYERII* *LATIFASCIA*
(NYMPHALIDAE)

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REPORTS OF MOSAIC AND BILATERAL GYNANDROMORPHS in the Order Lepidoptera are relatively uncommon. Among the Macroheterocera, recent records are available only for the families Saturniidae (Hessel, 1964; Muller, 1966; and Manley, 1971) and Geometridae (Blanchard, 1969). In the Rhopalocera, examples have been cited in four genera: *Speyeria* (Grey, 1959), *Colias* (Emmel, 1964; Hovanitz, 1965), *Lycaena* (Opler, 1966) and *Pieris* (Shapiro, 1970). It is the intent of this article to cite the discovery of a bilateral gynandromorph of *Limenitis*, thus adding one more genus to the list of butterfly genera in which this unusual phenomenon is known to occur.

Captured by the junior author at Coal Creek Campground, 2.7 mi. W. of Teton Pass, Teton County, Wyoming, 7100' el., on 9 August 1972, the specimen (Fig. 1) was netted as it glided slowly along a willow-bordered creek that traverses one of the many wet meadows to be found in this mountainous setting of aspen and conifer. Upon inspection, it was determined to be a freshly-emerged example of *Limenitis weidemeyerii latifascia* (Perkins & Perkins, 1967).

Female in appearance on its right side and male-appearing on the left, the specimen's bilateral asymmetry, including its antennal length, is obvious. The radius of the right forewing is 45 mm., whereas that of the left is only 40 mm. Genitalia are predominantly female.



Fig. 1.—Bilateral gynandromorph of *Limenitis weidemeyeri latifascia* Perkins & Perkins, 2.7 mi. W. Teton Pass, Teton Co., Wyoming, 7100' el., 9-VIII-72, leg. T. F. Perkins.

As discussed by DeWilde (1964), the bilateral gynandromorphism of this specimen might be explained either by the loss of x-chromatin during the zygote's first cell division or by the occurrence of a binucleate ovum of which only one nucleus was fertilized. In either event, the resultant gynandromorph's developmental size is disproportional because the female cells are known to be larger.

The specimen has been retained in the authors' collection.

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AN INTERFAMILIAL COURTSHIP (NYMPHALIDAE, PIERIDAE)

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ATTEMPTED MATINGS INVOLVING widely different butterfly species are seldom reported (Downey, 1962; Shapiro, 1973). On 11 August 1972 a bizarre instance was observed near Willow Slough, between Davis and Woodland, Yolo Co., California. This involved a male Buckeye, *Precis coenia* Hubner, courting a white female Orange Sulphur, *Colias eurytheme* Boisduval.

Several hundred *C. eurytheme* of both sexes were feeding at blossoms of alfalfa and yellow star-thistle (*Centaurea solstitialis*) along the dirt road at the west border of a newly-cut alfalfa field. Five male *P. coenia* were spaced along the road, behaving territorially. The observation began at 1816 hours, with a clear sky, light southerly wind, and air temperature in the mid-80s F. One male Buckeye rose as a white female flew over its perch, following it closely some fifteen feet until it lit and began to feed on a blossom of *C. solstitialis*. The *Precis* lit on the same blossom, just behind the *Colias* and slightly below it, and began moving about and curving its abdomen to the (observer's) left in a repeated attempt to make genital contact with the female, which shortly became quiescent. After about three minutes the *Colias* flew a few inches to another flower, the *Precis* following and resuming its attempts to mate. The female never showed any recognition of the male's presence. The pair was then collected for examination: the *Precis* male was extremely fresh, the *Colias* female somewhat worn, with one large intact spermatophore and many mature or near-mature ova. Female *Colias* in this condition generally display rejection behavior to courting males of their own species (Shapiro, 1970).

The remaining four *P. coenia* were watched for another half hour but no unusual behavior was noted, and no females of that species were seen. Pairs of *C. eurytheme* in copula were common, however. There is no resemblance in color or pattern between *C. eurytheme* and *P. coenia*, and no apparent basis for this male's "mistake."

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ADDITION TO:
A CHECKLIST OF UTAH BUTTERFLIES
AND SKIPPERS

By CURTIS J. CALLEGHAN and NORMAN B. TIDWELL
10(3):191-202, 1972(1973)

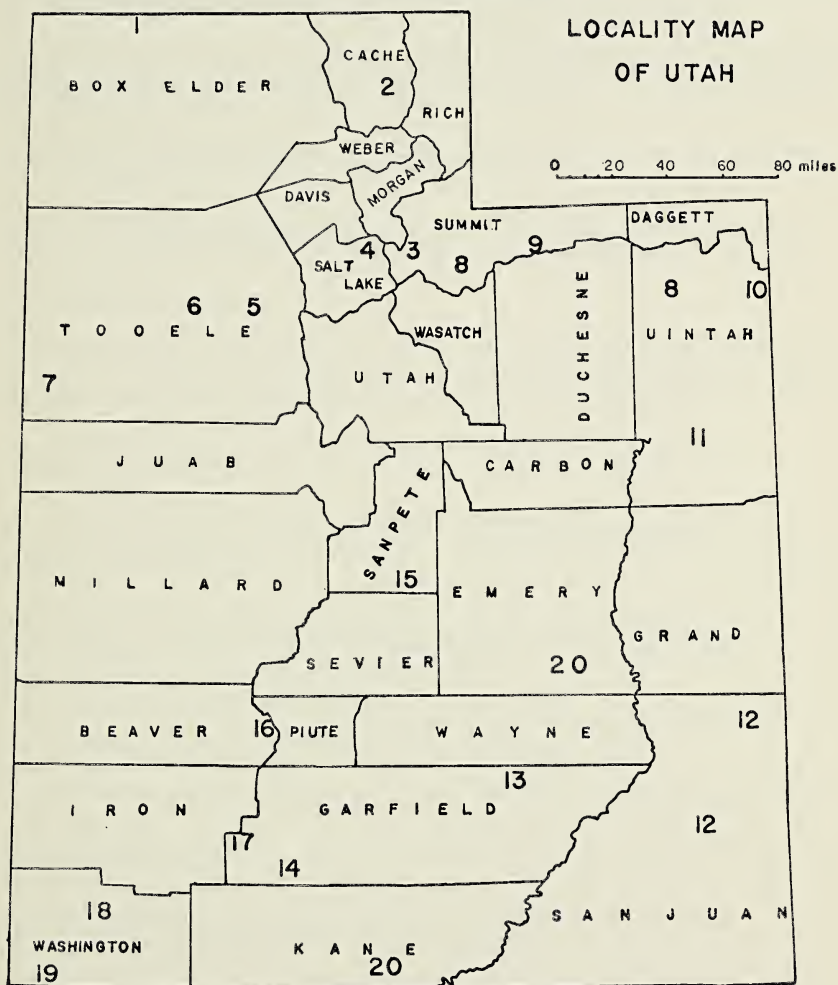


Fig. 1.—Locality map showing the counties of Utah.

NOTICES

WANTED:

Moths of the family Hepialidae in papers or sealed in container with chlorocresol, also larvae and pupae in Bles or similar solution, for distribution study of North American species. Norman E. Tindale, 2314 Harvard Street, Palo Alto, Calif. 94306.

Distributional records and data on habitats and habits for "A biogeographic study of Speyeria diana", by Dr. W.J. Reinthal and J.T. Mithell. Send data to Dr. W.J. Reinthal, 4026 Sequoyah Ave., Knoxville, Tenn. 37919.

Sphingidae of the world. Need particularly Proserpinus vega and P. desepta and Euproserpinus weisti and E. euterpe from the U.S.A. William E. Sieker, 119 Monona Ave., Madison, Wis. 53703.

Exchanges with lepidopterists. B. de los Santos Garcia. Av. Jose Antonio, 349, 2°, Barcelona-4, SPAIN.

Records of Speyeria zerene hippolyta. Edwin M. Perkins, Div. Biol Sci., University of Southern California, University Park, Los Angeles, Calif. 90007.

LITERATURE RECEIVED:

BIO QUIP PRODUCTS, catalogue of field, laboratory and storage equipment for the natural sciences. Mailing address: P.O. Box 61, Santa Monica, Calif. 90406. Main office and plant: 316 Washington St., El Segundo, Calif. 90245.

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Volume 11

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IN THIS ISSUE

- | | | |
|---|---|-----|
| Gynandromorphism in <i>Pieris brassicae</i> L. | Brian O. C. Gardiner | 129 |
| Two new subspecies of <i>Euphydryas</i>
<i>chalcedona</i> from the Mojave desert of
Southern California | T. C. Emmel and J. F. Emmel | 141 |
| Butterflies of middle and southern
Baja California | Richard Holland | 147 |
| Vital staining as evidence for wing
circulation in the cabbage butterfly
<i>Pieris rapae</i> | John M. Kolyer | 161 |
| A dwarf form of <i>Euptoieta claudia</i> | Russell A. Rahn | 174 |
| Butterfly records for three northwest
Wisconsin counties | John H. Masters | 152 |
| Variations of <i>Parasemia parthenos</i> | A. E. Brower | 183 |
| A search for <i>Speyeria nokomis coerulescens</i>
(Holland) (Nymphalidae) in southern Arizona | Ronald S. Wielgus | 187 |
| A bilateral gynandromorph of <i>Limenitis</i>
<i>weidemeyerii latifascia</i> (Nymphalidae) | E. M. Perkins and T. F. Perkins | 195 |
| An interfamilial courtship (Nymphalidae, Pieridae) | Arthur M. Shapiro | 197 |
| Addition to : "A checklist of Utah butterflies
and skippers | Curtis J. Callaghan and Norman B. Tidwell | 199 |

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LATITUDINAL GRADIENTS IN SPECIES DIVERSITY OF THE NEW WORLD SWALLOWTAIL BUTTERFLIES

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IT HAS LONG BEEN REALIZED that many taxa are represented by more species in the tropics than at higher (especially northern) latitudes (Wallace, 1878). Butterflies (Hovanitz, 1958), dragonflies (Kennedy, 1928), trees (Dobzhansky, 1950; Cain and Castro, 1959), mammals (Simpson, 1964), birds (MacArthur, 1964; Karr, 1971), snakes, lizards and other groups (Fischer, 1960) follow this broad trend of increasing species diversity from northern latitudes toward the tropics. Although recent studies have greatly expanded our understanding of the causes of high diversity in tropical areas (Connell and Orias, 1964; Pianka, 1966; Saunders, 1968; MacArthur, 1969; Karr, 1971; and others), there seems to be no general explanation for all increased tropical diversities, and the importance of the various causes may vary with the taxa being studied. In the present paper latitudinal gradients in species diversity are examined for a particular group of butterflies. An attempt is then made to interpret the factors which contribute to the observed patterns and to fit these factors into an acceptable theory.

The group chosen is the New World swallowtail butterflies of the subfamily Papilioninae, family Papilionidae. An advantage of studying this group of herbivores over many others is that the geographical ranges of the adults and the feeding habits of the larvae are reasonably well known (Edwards, 1868-1897, 1889; Reed, 1877; Burmeister, 1879; Gundlach, 1881; Scudder, 1889; Rothschild and Jordan, 1906; Silva, 1907; D'Almeida, 1922, 1966; Jordan, 1924; Dethier, 1940; Bourquin, 1944; Wolcott, 1948;

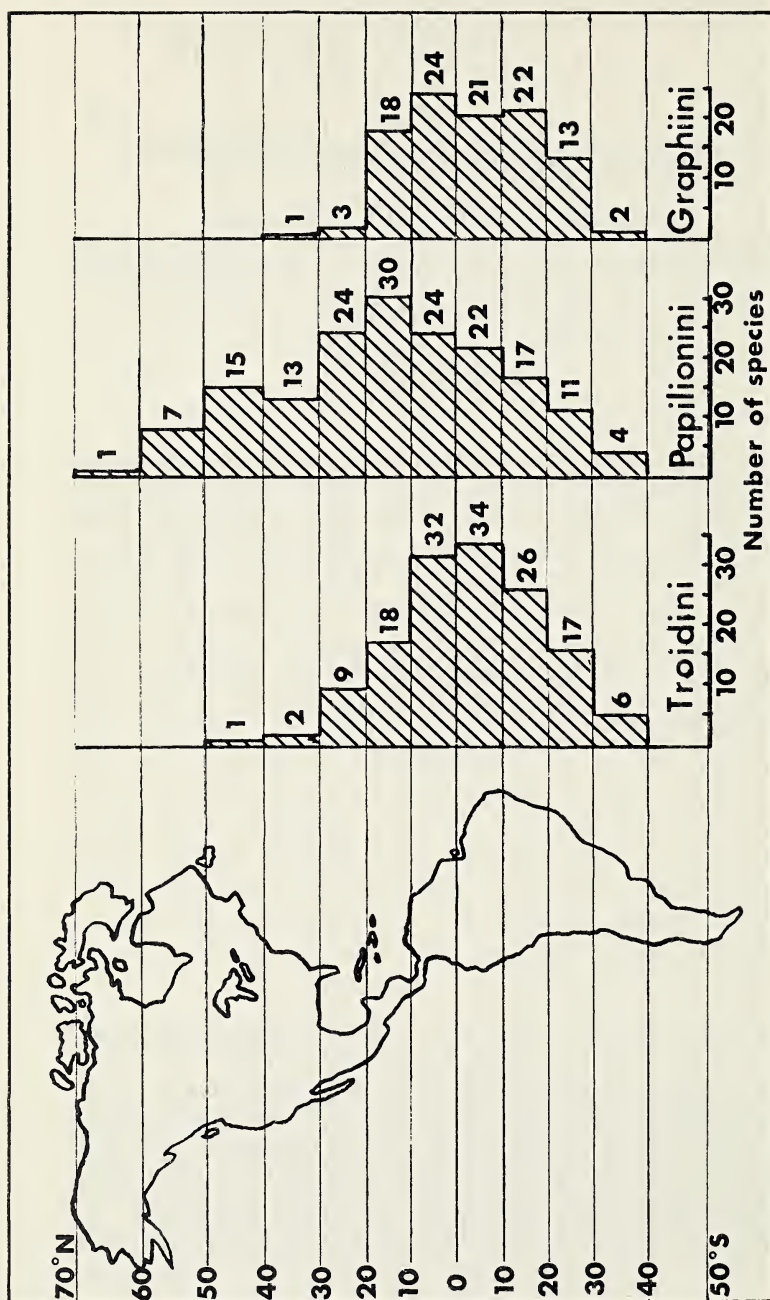


Fig. 1. - Map of New World showing latitudinal gradients in numbers of species of three tribes of swallowtail butterflies.

Bauer, 1955; Pronin, 1955; Biezanko, 1959; Brower, 1959; Klots, 1960; Munroe, 1960; Ehrlich and Ehrlich, 1961; Brooks, 1962; Newcomer, 1964; Ross, 1964a,b; Ehrlich and Raven, 1965; Brown and Mielke, 1967a,b; Costa Lima, 1968; Perkins, Perkins, and Shining, 1968; Holland, 1969). There are approximately 175 species of Papilioninae in the New World which are divided into three tribes on the basis of adult morphology, structure and food-plant associations of the larvae, pupal morphology, and geographic distribution (Munroe, 1960; Munroe and Ehrlich, 1960). These are the Troidini (about 60 species), the Papilionini (about 65 species), and the Graphiini (about 50 species).

METHODS

Measurement of species diversity

Sophisticated measures of diversity of species within natural communities have been developed in recent years (see Pianka, 1966; Pielou, 1969; Whittaker, 1970a; and references therein). Because such measures generally require knowledge of the relative abundances of the component species, and because such data for the swallowtails are lacking, diversity is here represented simply as the number of species per latitudinal belt, arbitrarily chosen to be 10° latitude in width.

Swallowtail ranges and food-plant records

Data on the geographical ranges of the swallowtails were taken primarily from Rothschild and Jordan (1906). Since 1906 about twelve new species have been described and these are included in the present discussion where their ranges are known. In the few cases where two or more species have been synonymized (Munroe, 1960), their ranges have been combined.

Latitudinal ranges were represented graphically in terms of the presence or absence of a species within successive latitudinal belts. Ranges were assumed to be continuous from the northernmost record to the southernmost record of collection, a reasonable assumption except perhaps for a few, extremely wide-ranging species. The numerous maps of individual species ranges are not included here for reasons of spatial economy. The graphic representation of these ranges implies both a static temporal and spatial distribution. However, apart from obvious seasonal fluctuations and migrations, the ranges of these butterflies may be expanding or contracting, either naturally or more likely through man's activities.

TABLE 1

Distribution of larval food-plant families and of swallowtails feeding upon these plants.
Most important families are underlined.

Tribe	Distribution	Food-plant family	Distribution	References to plant distributions
Troidini	Mainly 20° N to 30° S latitude	Aristolochiaceae, <u>Rutaceae</u>	Ari.: mainly tropical, fewer than 20 sp. in U.S. and Canada; 80 sp. in Brazil and surrounding countries. Rut.: mainly sub trop. and trop.	Planchon, 1891; Patterson, 1892; Hoehne, 1927; Fernald, 1950.
	Most between 30° N and 30° S latitude	Rutaceae, Berberidaceae, Lauraceae, Piperaceae	Rut.: mainly sub trop. and trop., fewer than 20 of some 400 New World sp. in U.S. Commercial citrus between 35°N and 35°S lat. Ber.: north temperate and mount. S.A. Lau., Pip.: mainly sub trop. and trop.	Patterson, 1892; Record and Hess, 1940, 1942; Fernald, 1950; Trellease and Yunker, 1950; Yunker, 1953; Hutchinson, 1959; Bernardi, 1962; Reuther, Webber, and Batchelor, 1967.
Papilionini	Mainly north of 30° N latitude	Umbelliferae, <u>Compositae (Artemisia)</u>	Umb.: mainly temp., 250 sp. in N.A., 50 sp. in Mexico, few in trop. S.A., mostly in mount. regions, 50 sp. in southwestern S.A. Com. (Artemisia): north temp. and southern S.A.	Coulter and Rose, 1888; Patterson, 1892; Britton and Brown, 1913; Dethier, 1941; Mathias and Constance, 1950, 1967; Good, 1953; Matuda, 1958.
	Most north of 30° N latitude	Corylaceae, Lauraceae, <u>Magnoliaceae</u> , <u>Oleaceae</u> , Rosaceae, Rutaceae, Betulaceae, Platanaceae, Rhamnaceae, Salicaceae Saxifragaceae	Mostly north temp.: Bet., Cor., Mag., Ole., Pla., Ros., Sal. Sub trop. and trop.: Lau., Rut. Rha.: temp. and warm regions. Sax.: mainly cold and temp. regions.	Britton and Brown, 1913; Good, 1925; Hutchinson, 1959, 1964, 1967; Brockman, 1968.
Graphini	Mainly 20° N to 30° S latitude	Amonaceae, Lauraceae, <u>Magnoliaceae</u> , Verbenaceae	Ann.: mainly trop., less than 10 sp. in U.S., 600 sp. from Mexico to southern Brazil and northern Argentina, few further south. Lau., Ver.: sub trop. and trop. Mag.: north temp.	Patterson, 1892; Fries, 1930, 1931, 1934, 1937, 1939; Fernald, 1950; VanderWyk and Canright, 1956; Hutchinson, 1959.

Food-plant records were extracted largely from Ehrlich and Raven (1965) and references therein. Where other sources were consulted, food-plant records were evaluated with considerable caution (Shields, Emmel, and Breedlove, 1969).

RESULTS AND DISCUSSION

A map of the New World showing the latitudinal gradients in species diversity for the three tribes of swallowtail butterflies is represented in Figure 1. It is clear that the New World Papilioninae exhibits a latitudinal gradient of increasing species diversity, with the number of species increasing from the high northern latitudes (one species between 60° and 70° N latitude) to the tropics (149 species between 20° N and 20° S latitude) and then decreasing southward (12 species between 30° and 40° S latitude). The three tribes exhibit this gradient to varying degrees: the Troidini and Graphiini are restricted mostly to tropical and subtropical regions; the Papilionini has the widest and most northern distribution.

The distribution of the main larval food-plant families and of the swallowtails feeding upon these plants are given in Table 1. It can be seen that the greatest diversities of the swallowtail butterflies are in the areas where their main larval food-plant families are apparently most diverse in terms of numbers of species, and that these areas, for many of the main food-plant families, are the tropical and subtropical regions.

Two questions merit further discussion. What factors limit the northernmost and southernmost distributions of these swallowtail butterflies? And what factors are responsible for the observed increased tropical diversity of these swallowtail butterflies?

Limiting factors in the north

The northernmost range of insects in general is clearly limited by the physiological effects of low temperature. In addition a low annual heat budget, severe and often variable weather, and the continuous light of the short growing season affect both insects and plants, but apparently the decrease in insect species is greater and probably somewhat independent of the reduction in plant species (Downes, 1964). Only *Papilio machaon*, and Umbelliferae-feeder, is found north of 60° N latitude where at least three other possible swallowtail food-plant families are represented (i.e., Betulaceae, Compositae, and Salicaceae; Hansson, 1953). The few butterfly species found in the Arctic usually

have increased melanism and hairiness, which, together with the habit of basking, allow them to absorb solar radiation and achieve the body temperature necessary for flight (Downes, 1964; Watt, 1968).

Downes (1964, p. 279) concluded:

The arctic is not inherently simple and does not forbid a greater diversity, yet in fact very few species occur. . . . the arctic will always tend to lie towards the limit of the physiologically possible range because in fact the greatest continuity of evolutionary history has been in the tropics and most forms of life have thus been shaped in response to tropical conditions.

Limiting factors in the south

None of the species considered here is known to extend south of 40° S latitude. All but one species found at this southern limit of distribution mainly follow the tropical rain forest climate southward through eastern Brazil and into the permanently humid grassland climate of eastern Uruguay and north-eastern Argentina where broadleaf evergreen and deciduous trees break up into patches surrounded by grass and other herbaceous plants (Kuchler, 1952). Further south the pampas merge into the arid, sterile plains of Patagonia, where only scanty vegetation grows in stony, exposed, and excessively dry conditions (Campbell, 1944).

The only other species found south of 30° S latitude is apparently isolated in the vicinity of Valparaiso (western Chile) by the Andes to the east and the practically rainless and barren Atacama desert to the north, a region which has been called "one of the driest, least fertile areas in the world" (Good, 1933). Rainfall is greater in west central Chile and somewhat further south, and a broadleaf evergreen and deciduous rain forest is present (Good, 1933; Kuchler, 1952). Although there is little similarity to the Arctic zone of the Northern Hemisphere, this southwestern rain forest gives way to a sub-Antarctic flora further south (Campbell, 1944). Aside from a few microlepidoptera, southern Chile is lacking in moths and butterflies (Kuschel, 1960).

Darlington (1965) cited many instances of numbers of species decreasing from central to southern South America. As an explanation of this decrease he suggested the increase in intensity toward the south of such factors as cold, alteration of seasons, shortness of days in winter, and lack of warmth in summer. Thus, while in the extreme south low temperature

seems to be the major limiting factor in insect distribution, it appears that lack of moisture and the resulting scarcity of vegetation are the factors limiting the southward distribution of the swallowtails. Although a favorable area exists in west central Chile, these butterflies are hindered from entering it by the hot northern Chilean desert, the cold southern Argentinean desert, and the Andes mountains surrounding it.

Tropical diversity

Certainly the greater vegetational diversity in the tropics creates a greater variety of food for the swallowtails, but this greater vegetational diversity is only a proximate explanation, as Simpson (1964) has pointed out. In other words, given that the Umbelliferae-feeders are more diverse in regions where the Umbelliferae is more diverse, and that the Aristolochiaceae-feeders are more diverse in regions where the Aristolochiaceae is more diverse, the question remains as to why there are not 60 or 70 species of Umbelliferae-feeders (instead of 10 to 15) with some 250 species of Umbelliferae available in the north temperate zone, and why there are not only 10 or 15 species of Aristolochiaceae-feeders (instead of some 60) with only about 80 species of Aristolochiaceae present in the New World tropics.

Part of the answer becomes apparent when the evolutionary history of the Papilionidae is examined. Based upon various lines of evidence it is believed that the butterflies in this family evolved and diversified in tropical areas on Aristolochiaceae and that as they spread into regions where this plant family was not well represented or absent, they exploited other plant families chemically similar to the Aristolochiaceae (Munroe and Ehrlich, 1960; Ehrlich and Raven, 1965). Many species in the Graphiini and Papilionini feed upon Annonaceae, Lauraceae, and Magnoliaceae, which, in addition to some other plant families, form a closely allied group in the order Ranales (Ehrlich and Raven, 1965) (i.e., Magnoliales; Cronquist, 1968). The Aristolochiaceae and families in the Magnoliales share some similar alkaloids (Alston and Turner, 1963; Hegnauer, 1963), and are apparently closely related in certain morphological structures as well (Thorne, 1963). A few Aristolochiaceae-feeders and many species in the Papilionini feed upon Rutaceae, a family containing some alkaloids in common with families in the Magnoliales, as well as other alkaloids (Hegnauer, 1963; Price, 1963). Some families in the Magnoliales (e.g. Magnoliaceae and Lauraceae), the Rutaceae, and the Piperaceae all have some species which contain various essential oils in common with the Umbelliferae

(Dethier, 1941). Cyanogenic, phenolic and other glycosides are found in Betulaceae, Oleaceae, Salicaceae, and Rosaceae (Paris, 1963), all of which are larval food-plants for some species in the Papilionini. From the feeding relationships of these three tribes of swallowtails and the chemical relationships among the food-plant families it is apparent that the swallowtails feed upon a number of chemically, if not taxonomically, related plants. In fact, the food-plant preferences of many insects are apparently of a chemical nature, dependent upon the secondary chemical content of the plants (Fraenkel, 1959; Dethier, 1970; Whittaker and Feeny, 1971).

On the basis of the distribution of certain of these compounds and the feeding habits of various species in the Papilionini, a gradual transition in feeding habits from the Rutaceae (containing alkaloids) through intermediate food-plants (with various combinations of alkaloids and essential oils) to the Umbelliferae and a few chemically related Compositae (i.e. *Artemisia*) (containing essential oils) has been suggested (Dethier, 1941). A more abrupt transition might also have occurred as certain facultatively polyphagous papilionid larvae (i.e. larvae 'normally' feeding on a particular plant but able to feed and survive on certain other plants if given the opportunity) exploited ovipositional variability in adult females by surviving on the 'abnormal' food-plant and produced adults which generally prefer to oviposit on the new food-plant (Stride and Straatman, 1962; see also Hovanitz, 1969).

The Umbelliferae-feeders, in changing their feeding habits from the rest of the Papilionini, chose a family of plants characteristic of temperate areas. The Umbelliferae is apparently more recently evolved than the Aristolochiaceae (Cronquist, 1968), and thus its swallowtail fauna may not yet have had enough time to reach maturity or saturation (e.g. Southwood, 1961) as evidenced perhaps by the fact that the Umbelliferae-feeders are restricted mainly to plants in only one of three sub-families in the Umbelliferae (Ehrlich and Raven, 1965).

Another factor apparently involved in the increased tropical diversity exhibited by these butterflies is the relatively predictable, favorable climate of much of the New World tropics. From approximately 20° N to 20° S latitude at low altitudes there is no frost, monthly rainfall variability is less than 20% of the mean, the maximum annual temperature range is usually much less than 30° F, and the average daily temperature range is usually greater than the average annual temperature range.

Although this is a broad generalization subject to considerable exceptions, these factors qualify this area as one of "maximum climatic stability" (Klopfer and MacArthur, 1961).

A number of important considerations arise from this generalization: 1) Evolution in general is usually considered to be faster in the tropics than in other areas (Dobzhansky, 1950; Darlington, 1959) and this might particularly be expected to be true for the evolution of insects. Insects, being poikilothermic, are directly dependent upon the external temperature and a warmer, more favorable temperature for a longer period of time might be expected to increase mutation rate and the number of generations per year and thus increase the appearance of favorable mutations and gene complexes (De La Rue, Bourliere, and Harroy, 1957; Carcasson, 1964; Stehli, Douglas, and Newell, 1969). While evidence of increased tropical mutation rates is lacking, it has been known for a long time that larval development in insects may be facilitated by increased temperature (Dimmock, 1888) and it is common for many butterflies to exhibit one or more additional broods in the southern parts of their ranges than in the northern parts (Klots, 1960). Although some of the swallowtails reported here, including both those found in the region of climatic stability and those found outside it, breed all year long, brood following brood, many also exhibit predictable, seasonal-like variations, especially in regard to changes in rainfall. These periods of abundance and scarcity of the swallowtails are undoubtedly often due to corresponding periods of abundance and scarcity of the larval food-plants (such as occurs in temperate regions) but they also occur in some species even though larval food-plants continue to be present, perhaps being due to changes in the availability of adult food sources (Rothschild and Jordan, 1906; Wiltshire, 1959; D' Almeida, 1966; Emmel and Leck, 1969; M. Barcant, K. S. Brown, A. Cardoso, G. Kesselring, M. Serrano, T. Turner, personal letters). Thus no generalization regarding an increase in the number of generations and hence a supposed increased rate of evolution of the swallowtails in the region of climatic stability is possible.

The year long favorable climate does however allow a high number of swallowtail species to be found at any month of the year, while the cold months of the north temperate zone and the dry months of the south temperate zone prevent most swallowtails from flying during these harsh times (Table 2). This factor may be causally related to the increased tropical diversity

observed in these swallowtails but its actual implications are not clear.

2) Local animal diversity is in some cases directly related to the number of predators in the system because these prevent any one species from monopolizing a limited resource and thus allow more species to coexist. Areas with increased stability of annual production, such as the tropics, are apparently able to support more predators and consequently be more diverse (Paine, 1966). Although data on swallowtail predation are practically non-existent, one might expect that predation in the tropics, of adults at least, is an important factor because of the existence of a great number of mimicry complexes (Rothschild and Jordan, 1906; Sheppard, 1961; Blest, 1966; Wickler, 1968). This apparent increased predation pressure may thus contribute to the increased tropical diversity of these swallowtails.

3) Species coexisting in a habitat apparently can be more similar if productivity is high, if individual species abundances are low (apparently true for tropical butterflies in general; Ebert, 1969), and if the seasons are relatively uniform (MacArthur, 1965), factors which generally describe much of the tropics. Niches apparently can be narrower in stable communities (MacArthur, 1955), and it has been mathematically determined that if niches are narrower, more species can coexist in a given environmental range (MacArthur and Levins, 1967).

TABLE 2

Number of swallowtails flying at each month of the year in the region of climatic stability (CS), in the area north of this region (NCS), and in the area south of this region (SCS)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CS	38	28	32	29	31	43	41	38	31	30	25	30
NCS	2	3	5	7	12	14	13	9	7	6	2	2
SCS	10	11	6	2	0	1	2	7	7	11	11	11

* Data for CS based on 77 species (about 67% of the total species found in that region); for NCS, 18 species (about 50%); and for SCS, 13 species (about 52%). Data compiled primarily from Rothschild and Jordan (1906).

For the swallowtails, data on one aspect of their niche, food-plant preferences, are available for study. It appears that the relatively general feeders (broad niche) are more prevalent in the north temperate zone (Table 1), probably because the advantage in a changeable climate lies with the general feeder that can switch to an alternate food-plant if its primary one is not available due to the vagaries of the climate. In the tropics, the butterflies can apparently specialize more (narrow niche) because they are more or less guaranteed the presence of their particular food-plant due to the favorable, relatively predictable climate. While this fits in well with the above mentioned theoretical considerations, at least two problems arise. One is that although there are a number of relatively general feeders in the north temperate zone, these feed primarily upon deciduous trees and shrubs, a rather stable and reliable food source when compared with short-lived annual herbs. The other is that due to the chemical nature of food-plant preferences, most butterflies are restricted in their choice of food-plants, usually to plants in one or two chemically related plant families, and even the relatively general feeders appear to show particular preferences in different parts of their ranges (Brues, 1920; J. M. Scriber, personal communication).

However, data on these swallowtails' ability to switch food-plants if necessary are lacking. Organisms in harsh regions (i.e. physically stressed and unpredictable environments) apparently maintain a high degree of genetic variability and consequently utilize a larger share of the resources than organisms living in favorable regions (i.e. stable and predictable environments) where genetic variability would be selected against because the disadvantages of a high genetic load would outweigh the advantages of high genetic flexibility in these more stable environments (Grassle, 1967). Thus it may be that temperate species are more 'plastic' in food habits than tropical species. Of course, many other factors are involved in determining a species' niche, and it appears that the contribution of this factor of niche breadth to the increased diversity of the tropical swallowtails is significant. Research to compare niche breadth in temperate and tropical swallowtails is currently underway in our laboratory.

The factors discussed above fit in well with the stability-time hypothesis developed by Saunders (1968) to account for increased tropical diversities. In physiologically harsh areas (harsh due to unfavorable physical conditions and increased physical fluctuations) organisms apparently must utilize a major portion of their energy budget for coping with the physiological stresses,

but in favorable areas (favorable due to reduction in harsh physical conditions and in physical fluctuations), organisms are apparently subjected to increased biotic stresses (e.g. competition and predation) such that a major portion of their energy budget is utilized in the coevolution of complex communities (see also Karr, 1971).

Thus what appears to have happened is a synergistic coevolution of plant-herbivore interactions, accentuated by the abundance of phytophagous insects in physiologically favorable tropical regions and resulting in increased diversity of both plants and herbivores (Brues, 1920; Gillett, 1962; Ehrlich and Raven, 1965). The fact that these interactions are basically of a chemical nature implies that, unlike bird diversity which apparently depends primarily upon the structure of the community and broad food categories and thus becomes saturated (MacArthur, 1964; 1969), unlimited possibilities exist for the continued increase in terrestrial plant and insect diversities (Whittaker, 1969; 1970b), provided man radically and rapidly alters his policy of worldwide environmental destruction.

SUMMARY

Latitudinal gradients in species diversity are examined for the New World swallowtail butterflies in the subfamily Papilioninae, family Papilionidae. Species diversity is measured as the number of species present per 10° latitudinal belt, determined from the literature. The three tribes in the Papilioninae (the Troidini, the Papilionini, and the Graphiini) are shown to exhibit to varying degrees a pattern of increasing species diversity from high northern latitudes (one species between 60° and 70° N latitude) to the tropics (149 species between 20° N and 20° S latitude) and then decreasing southward (12 species between 30° and 40° S latitude). It is also shown that these swallowtail butterflies are most diverse in areas where their main larval food-plant families appear most diverse.

Factors limiting the general overall distribution of these swallowtails are interpreted to be mainly the adverse effects of low temperature in the north and the lack of moisture and resulting scarcity of vegetation in the south. Factors which are considered important in their contribution to the increased tropical diversity of the swallowtails include: 1) the diversity of the main larval food-plants, which for many of the main food-plant families (i.e. Aristolochiaceae, Annonaceae, and Rutaceae)

is greatest in subtropical and tropical areas; 2) the evolutionary history of the Papilionidae, the primitive stock of which apparently evolved and diversified in tropical areas; and 3) the predictable, favorable climate of much of the tropics, which allows a high number of swallowtail species to be found at any month of the year. This favorable climate apparently also allows increased predation pressure as evidenced by the great number of mimicry complexes in tropical butterflies and probably allows increased similarity and specialization of the tropical swallowtails. These factors are intermeshed in the synergistic coevolution of plants and herbivores, mainly on a chemical level, which has resulted in the more complex communities of these tropical areas.

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*Cover Illustration*LACK OF MELANISM IN *COLIAS*

Photo of *Colias eurytheme* male supplied by John H. Masters of specimen in the collection of Dr. Mance Brackney of Minneapolis, Minn.; collected in Hennepin County, Minn. Dorsal and ventral views are shown. The specimen appears to be normal except for the absence of all black pigmentation. This is the same specimen shown in *J. Lepid Soc.* 22:158, 1968.

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A POPULATION STUDY OF *EUPTYCHIA HERMES* IN NORTHERN FLORIDA

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THE POPULATION BIOLOGY of the satyrid butterfly *Euptychia hermes* Fabricius has been described in relation to a tropical population (Emmel, 1970). However, little work has been done on the species in the northern temperate zone. Since this *Euptychia* ranges in the United States as far north as the New England states along the Atlantic Coast and as far south as central South America, comparative population studies should be of considerable biological interest. The present paper treats a population in Gainesville, northern Florida.

MATERIAL AND METHODS

Euptychia hermes is a small dull brown-gray butterfly with a wingspread of approximately 25 mm. Its underside has conspicuous submarginal ocelli and is lighter colored than the dorsal surface of the wings. The larvae of the species feed on grasses but the adults appear to spend much time amongst decaying leaf litter found on the forest floor. The characteristic flight movement rarely exceeds two feet in height or five feet lateral distance and is especially distinguished by a very slow beating of the wings. Little or no variation was observed from unidirectional flight except in times of pursuit. Having alighted on a surface, *E. hermes* does not open its wings; rather, it folds its wings over the thorax and orients toward the sun. This results in a minimization of the shadow cast.

The locality in which this population study was undertaken was in a thinly wooded area south of Bartram Hall on the University of Florida campus in Gainesville. The immediate area included an apiary, used by the Department of Entomology, two rarely used wooden buildings, and a greenhouse (see Fig. 1). North of these buildings in the area studied were a number

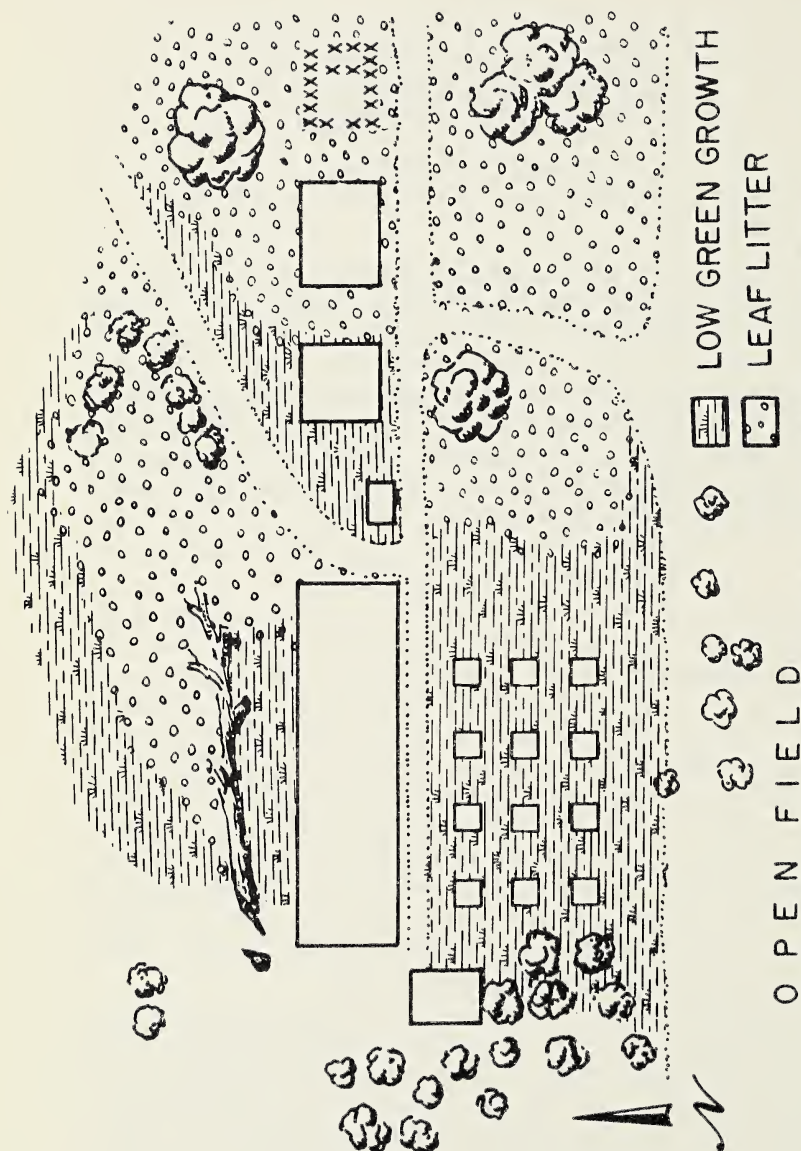


Fig. 1.—Map of the partially wooded area on the University of Florida campus where the present population study of *Euptychia hermes* was undertaken. Dotted lines indicate pathways through area. The apiary mentioned in the text is represented by small boxes at lower left. The east-west distance across the map is approximately 70 yards.

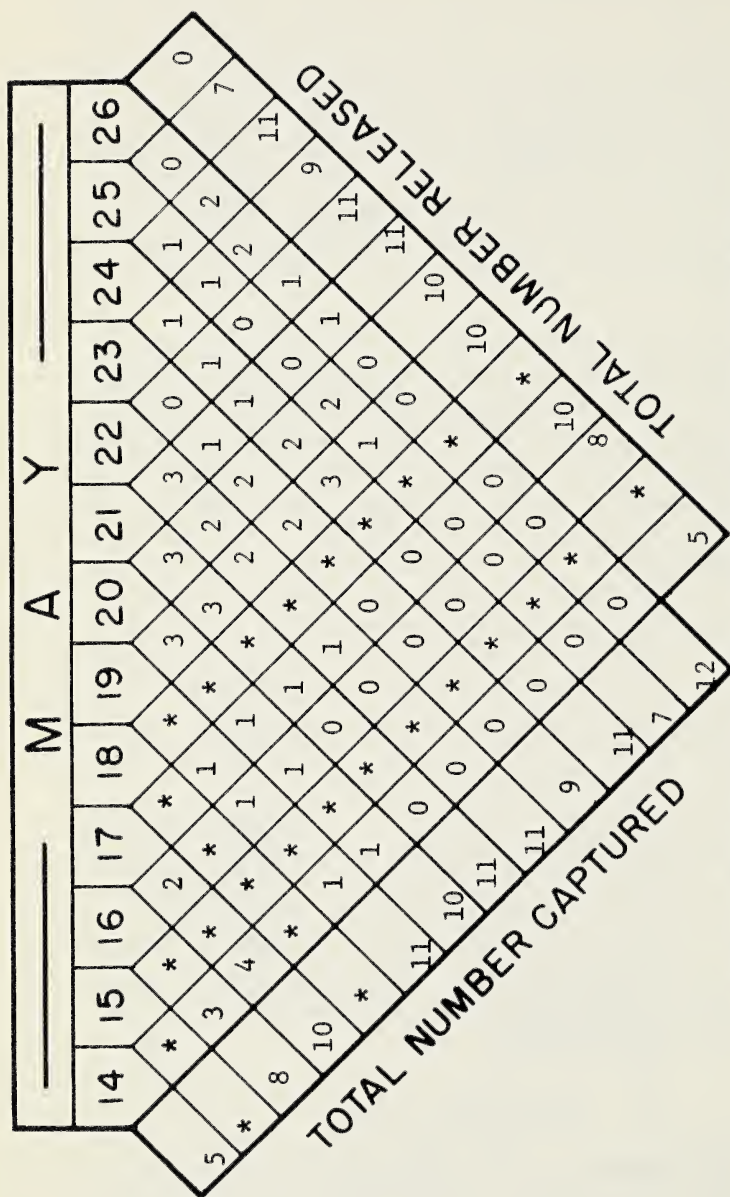
of pines but south of them were only two or three deciduous trees (hardwoods). However, one of these consistently had three or so individuals within five feet of its base and was initially thought to support a separate population (Tree A in Figure 1). The floor was worn by paths in some places but generally was covered by either decaying litter or short ($\frac{3}{4}$ m or less) green growth as noted in Fig. 1. North and east of this area was a less densely forested area of pines and south of it was an open field of low cropped green grass. For less than 15 m west of the area extended denser, wooded growth bounded by a campus road. The total area was approximately 70 m x 40 m.

A capture-release-recapture program was initiated on May 14 and continued until May 26, 1972, to determine population size as calculated by three applicable standard methods for population estimation. Specimens were marked with a green Magic Marker pen on their wings according to a 1-2-4-7 coding system (Ehrlich and Davidson, 1961). Collection was done for one hour periods each day from 3:45 to 4:45 P.M. as this time was found by observation to be a period of high activity for the butterflies and convenient for the author. Because *E. hermes* is a low-flying species, the most effective method of collection was waiting for flying individuals to land and then quickly placing the net over the insect. Raising the bag resulted in the specimen flying to the top. Individuals caught in this manner were held in nets until the collection period had terminated and were then released after marking.

The boundaries of the population were initially estimated by obvious geographic features and then adjusted after sampling gave a better indication of adult distribution. At three-day intervals, collection was attempted outside the tract depicted in Fig. 1. At no time was a marked individual seen or caught beyond the designated boundaries. Only one unmarked specimen was caught during these hours, approximately 40 m north-east of the collection area.

RESULTS

The capture-recapture data resulting from this work is summarized by the trellis diagram in Fig. 2. Estimates of population size (see Table 1) were obtained with these data using three statistical methods.



1. *Modified Lincoln Index* (Bailey, 1951):

$$P_1 = \frac{(N_2 + 1) M_1}{R_2 + 1}$$

where P_1 = population size on day one

M_1 = the number marked on day one

N_2 = the total number of captures on day two,
and

R_2 = the number of recaptures on day two

2. *Bailey's Triple Catch Method*

$$P_2 = \frac{M_2 N_2 R_{3_1}}{R_{2_1} R_{3_2}}$$

where P_2 = population size on day two,

M_2 = number of individuals marked on day two,

R_{3_1} = number of recaptures taken on day three
and marked on day one,

R_{2_1} = number of recaptures taken on day two and
marked on day one, and

R_{3_2} = number of recaptures taken on day three
and marked on day two.

3. *Capture per Unit Effort Method* (DeLury, 1947):

$$\frac{\text{No. captured at } t_0}{P_0} = \frac{\text{No. captured at } t_1}{P_1}$$

where P_0 = population size at time 0 and

P_1 = population size at time 1.

The population estimates for the modified Lincoln Index were calculated by a straightforward application of the formula. There was some problem in applying the Triple Catch Method of Bailey, which requires three consecutive days of data, because on May 23rd no recaptures were taken of individuals marked on the previous day. Thus, no estimates were available for either day and the same held true for the 25th and 26th of May. In using the Capture per Unit Effort method, the estimate for May 14 was taken directly from the modified Lincoln Index and this was used as P_{t_0} in the formula. Because this is a successive formula, the choice of initial population size influenced the population estimates for all later dates. The direct count of the total number caught is given for a means of comparison of the estimates to the minimum population size.

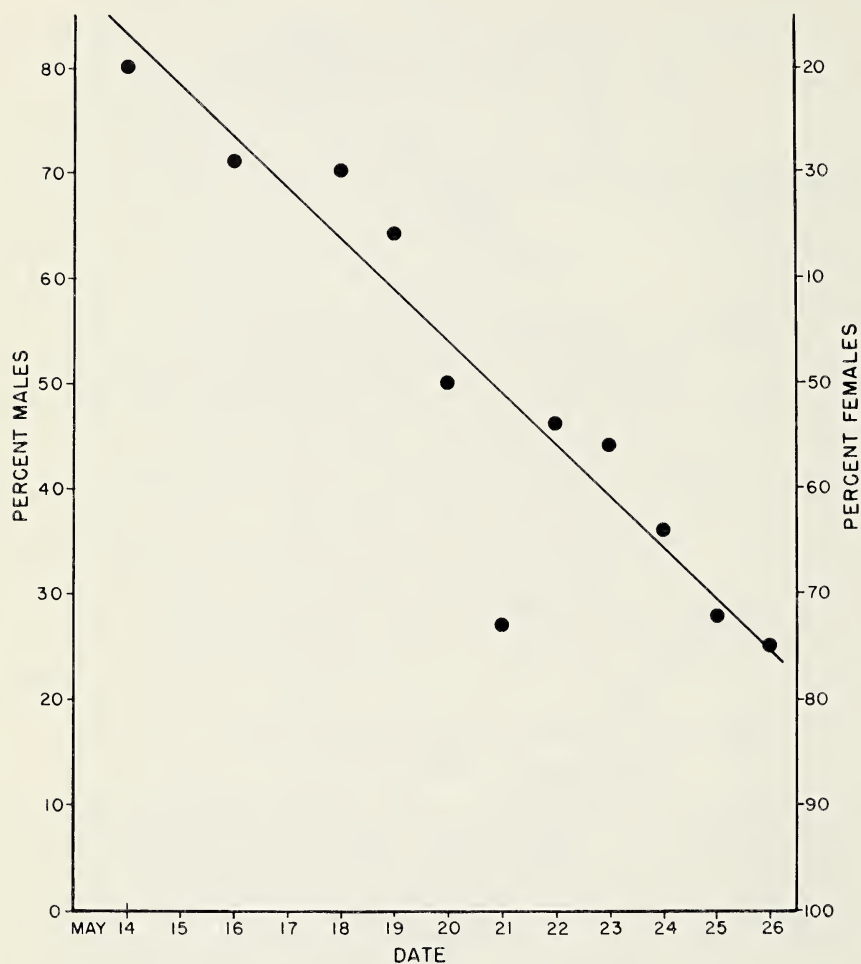


Fig. 3.—Decreasing percentage (left axis) of males in *E. hermes* population from May 14 to 26, 1972. The increasing percentage of females in the population is indicated on the right axis.

As is evident from the table, the greatest agreement is between the estimates derived from the modified Lincoln Index and the Capture per Unit Effort Method up to May 20th. Thereafter, a one-day lag in sensitivity between these two methods is noticed. These two methods also show a closer correlation with the direct total count than the Triple Catch Method. Intuitively speaking, the direct total count would be a reliable indicator of population size in this specific case because all individuals that were seen in the area each day were caught within the first 30 minutes of collection. If a balance between birth and death rate is assumed and since no emigration was observed, the only factor unaccounted for is immigration. This factor could explain the difference between estimated and direct counts. The smaller correlation between the Triple Catch Method estimate and direct count may be due to a lack of sensitivity to the small number of recaptures. The modified Lincoln Index has a correction factor for this and the Capture per Unit Effort Method calculations may have benefited by the use of the modified Lincoln Index figure for May 14.

Some of the most interesting data from the capture-recapture program were the changes in sex ratio during the 12 days. As the work progressed, there was a noticeable decrease in the number of males captured in relation to females. The decreasing percentage of males and corresponding increase in females captured is portrayed graphically in Fig. 3. A possible explanation of the increase in number of females is that a new, second generation of this multiple-brooded species is emerging at this time of year. At this point in the emergence of the adults of the population, males would have largely completed emergence earlier in the season and female emergence would now be reaching a peak. Another factor influencing the apparent sex ratio may be that the mature females would be flying about in the grasses laying eggs and hence perhaps be more active than males at this particular time.

Finally, Fig. 4 and 5 illustrate the number of times individuals were recaptured on different days. The marked decline in the graph is due to the short life span of the adults and the intersect on the horizontal axis indicates a maximum life expectancy of approximately 6.25 days for this *Euptychia hermes* population. Thus the graph itself approximates a survivorship curve. The survival rate ($r_{-}/$) at a particular time can be obtained by calculating the slope of the curve at that point. The survivorship rate declines strongly near the maximum life span.

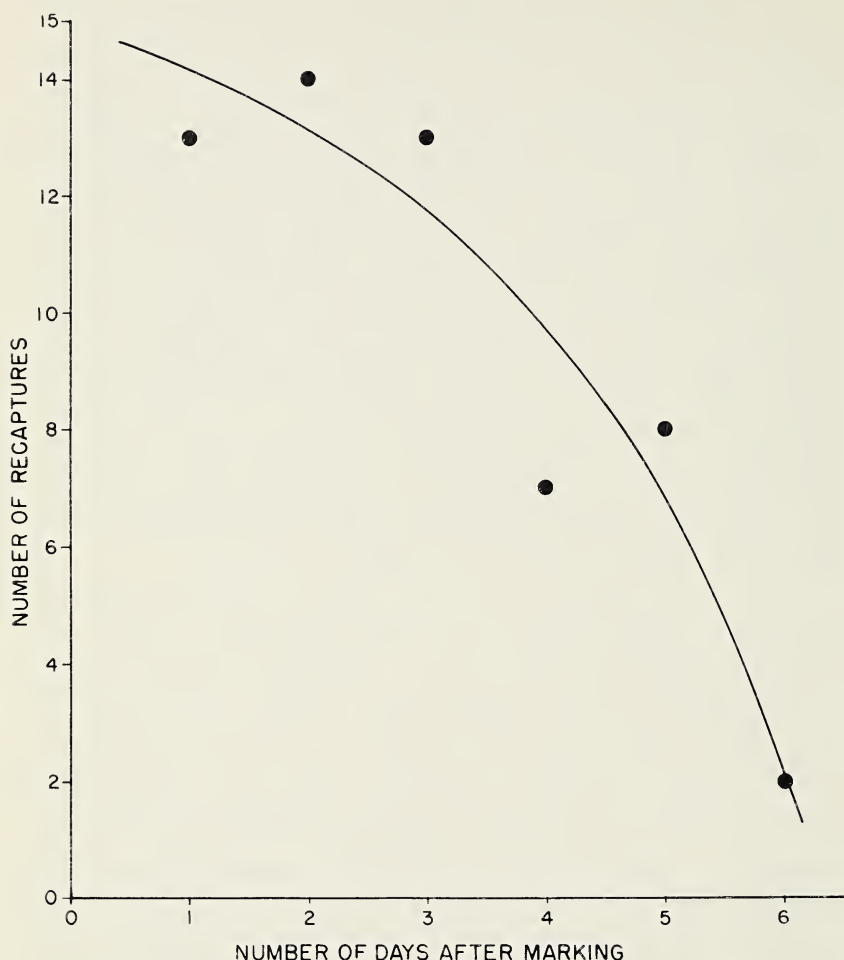


Fig. 4.—The number of recaptured specimens taken on successive days following initial marking. This graph gives an approximation of the survivorship curve for adult *Euptychia hermes* in this Gainesville, Florida population. The maximum expected life span in the wild is approximately 6.25 days.

SUMMARY

A project comparing three standard methods of population estimation was conducted with the satyrid butterfly, *Euptychia hermes* Fabricius, on the University of Florida campus in Gainesville. The modified Lincoln Index and Capture per Unit Effort Method were found to be the most sensitive to the small numbers of individuals in the *E. hermes* population studied. Some

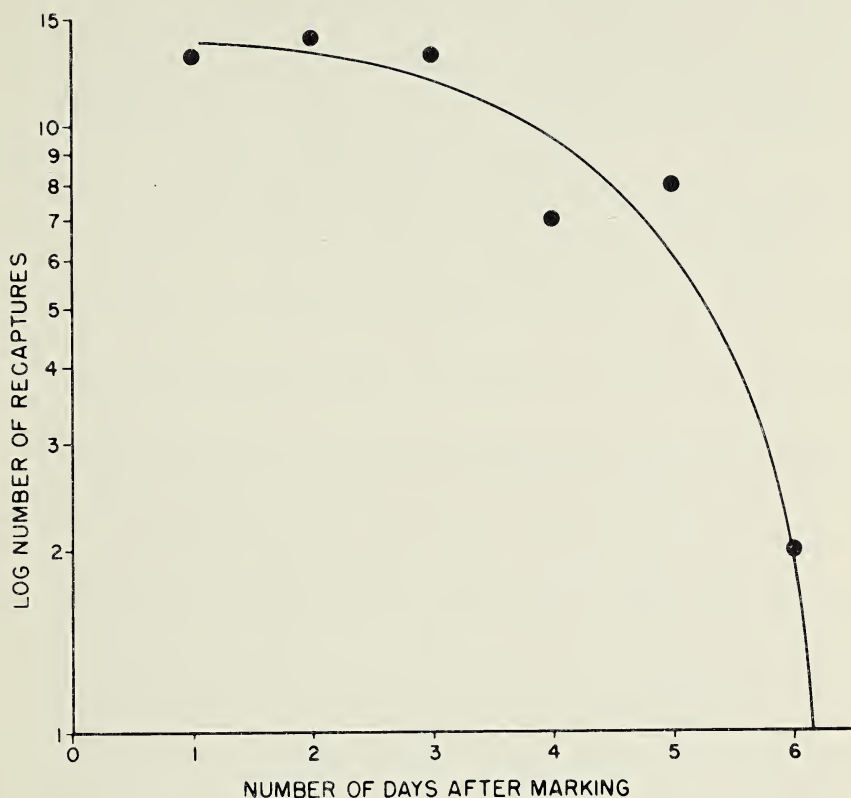


Fig. 5.—The log number of recaptured specimens taken on successive days following initial marking. See Fig. 4 and text for further explanation.

difficulty was encountered in applying Bailey's Triple Catch Method because of the requirement of recaptures on three successive days. The percentage of females in the population increased dramatically from 20 to 75% during the course of the project, probably due to the emergence of the second generation and increasing activity of egg-laying females. A survivorship curve with an expected average *maximum* of 6.25 days as life span for adults of both sexes was obtained.

ACKNOWLEDGMENTS

I wish to thank Dr. Thomas C. Emmel of the University of

Florida, who not only provided invaluable aid in preparing the manuscript, but also generated my initial interest in this field. This research was a byproduct of studies on chromosomal variation in *Euptychia hermes* populations and was partially supported by NSF Grant GB-32151 (T. C. Emmel, principal investigator).

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EDITORIAL CORRECTION REGARDING PRIORITY

Through inadvertent publication of the *Anartia amalthea* paper by Fosdick (1973) ahead of the preceding paper by Kilduff (1973), an incorrect interpretation of priority of ideas may be created.

As Associate Editor of this *Journal*, I received and reviewed both papers editorially. Thomas S. Kilduff's paper was accepted for publication on July 5, 1972, and transmitted to the editor on that date. Kilduff's research was done during May 1972, and his paper contained a number of novel treatments of data, including certain graphical renderings of maximum life expectancy and survivorship (Fig. 4 and 5) which had not previously been published.

Fosdick's data on the population biology of *Anartia amalthea* were collected in September 1972 and both this later study and his paper (Fosdick, 1973) were modeled after the excellent approaches used by Kilduff. Fosdick's paper then, was to be the *second* paper of the two to appear in the *Journal*. It was accepted for publication on November 22, 1972, and transmitted to the California editorial offices on that date. Unfortunately, in my review of the Fosdick paper as Associate Editor, I neglected to state that it contained full credit to Kilduff's prior paper for the treatment and ideas used, and I did not specify to the Editor that the July 1972 paper by Kilduff had to appear ahead of that by Fosdick (the order of appearance of papers in journals normally depends upon both the time received and the relative lengths of papers versus exact space needs for that journal issue). We wish to emphasize that full credit and future citations for the particular approaches utilized in the two papers should go to Kilduff (1973).

Thomas C. Emmel
Associate Editor

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LIMENITIS WEIDEMEYERII ANGUSTIFASCIA X
L. ASTYANAX ARIZONENSIS = (?) AB.
DOUDOROFFI (GUNDER), 1934,

IN THE ALLAN HANCOCK FOUNDATION COLLECTION¹
(NYMPHALIDAE)

EDWIN M. PERKINS, JR.²

and

JOHN S. GARTH³

THE RECENT DISCOVERY BY THE authors of an unusual *Limenitis* spp. in the Allan Hancock Foundation (AHF) collection at the University of Southern California prompted a search through the literature in an attempt to ascertain its identity. Taken at Oak Creek Canyon (fig. 1), Coconino County, Arizona on June 1, 1942, by J. S. Garth, the specimen had been identified tentatively as *L. weidemeyerii angustifascia* ab. *sinefascia* Edwards, 1882; however, it did not compare favorably with the holotype of *sinefascia* in the United States National Museum (UNSM No. 33964; see Perkins & Perkins, 1967).

Unique in appearance, the example in question is characterized by a black suffusion of scales throughout the basal and discal areas of all wings dorsally. Only in the limbal area of the hind wing (HW) is a slight bluish iridescence perceptible. Additionally, the dorsal row of submarginal markings on the HW is comprised of discrete, minutely elliptical, white pupils that contrast strongly with the otherwise somber black ground color—this in contrast to the melanic crescents of *L. weidemeyerii angustifascia* (Barnes and McDunnough), 1912, and the iridescent lunules of *L. astyanax arizonensis* Edwards, 1882.

¹Allan Hancock Foundation Contribution No. 000.

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⁴Gunder's designation "transition form" has no taxonomic standing, and dosPassos (1964) treated most such names as aberrations.



Fig. 1.—Looking north along the rim of Oak Creek Canyon, Cocconino Co., Arizona, *ca.* 6,000 ft. elevation.

The specimen, however, also possesses characteristics in common with both *L. w. angustifascia* and *L. a. arizonensis*.

Like *angustifascia* dorsally (fig. 2), it exhibits 3-4 submarginal white spots in cells R_3 - R_5 and M_1 in the apical area of the forewing (FW), and lacks the characteristic *astyanax* suffusion of blue-green iridescent scales on the limbal area of the FW and discal areas of the FW and HW. Like *angustifascia* ventrally (fig. 3), it possesses 5-6 submarginal white spots in cells R_3 - R_5 and M_1 - M_3 in the apical area of the FW, and exhibits 5 postbasal and submedian spots on the HW. Two of these, well defined in cells R_5 and M_1 , are situated directly cephalic to the larger, paired contiguous markings in the discal cell; unlike *angustifascia*, but like *arizonensis*, these markings are orange rather than white.

Like *arizonensis* dorsally and ventrally (fig. 2, 3), the specimen lacks the broad, median-postmedian white band on both FW and HW. Ventrally, it is similar to *arizonensis* in that the apical-subapical area of the FW is suffused with ferruginous—not black—scales; additionally it possesses a conspicuous series of orange, submarginal-postmedian lunules like *arizonensis* but unlike *angustifascia*, whose continuous submarginal-postmedian series of brick-red crescents resides lateral to the postmedian white band.

Consultation with Julian Donahue of the Department of Entomology at the Los Angeles County Museum of Natural History (LACM) and inspection of the Museum's collection yielded a specimen nearly identical to that in question; the only notable exception was the occurrence of white tufts of elongated scales in cell 2A in the region of the anal angle of the dorsal HW. Taken at Hannagan Meadows, White Mts., Greenlee County, Arizona, on July 21, 1941, by Fred W. Friday, it had been determined as *L. a. arizonensis* ab. *doudoroffi* (Gunder), 1934. Although terse, Gunder's original description generally coincides with those characters possessed by this and the Hancock specimen. Gunder treated *doudoroffi* as a transition form⁴, the holotype of which was taken at Tonto Creek, near Payson, Gila County, Arizona on July 12, 1933, by M. Doudoroff.

Bauer (1954) also reported taking a comparable specimen in Arizona's Verde Valley. Based upon his description, it too possesses one characteristic in common with both the LACM specimen and AHF example that is unlike any other specimens described or mentioned heretofore; namely the occurrence of

moderately distinct, bluish-white spots that constitute a median row in cells M_2 , M_3 and Cu_1 on the ventral FW.

It is tempting to speculate that the entity *doudoroffi* is not an aberration, as it is currently treated (dosPassos, 1964), but rather is a hybrid of *L. w. angustifascia* X *L. a. arizonensis*. Limited circumstantial evidence lends support to this hypothesis, as all such specimens manifest a combination of phenotypic color and patterning characters that are unique to one species or the other.

Altitude would appear to serve as an isolating mechanism. Bauer's 1954 report indicated that *arizonensis* was generally confined to the 4,000-5,000 foot levels (e.g., Sedona, Arizona at 4,250 feet), whereas *angustifascia* resided at or above the 6,000-foot elevations (e.g., Flagstaff, Arizona at 6,905 feet). However, it is known that the two species occasionally overlap and thus are capable of crossing such a barrier. Indeed, sympatry in the region of Oak Creek Canyon (between Sedona and Flagstaff is not uncommon; cf., G. Gorelick's July 29, 1969 records (J.L.S. "Season's Summary," 1970). Bauer (1954) reported collecting *Limenitis* larvae in the Oak Creek Canyon area on a narrow-leaved willow (*Salix*); those adults that emerged were both *arizonensis* and *angustifascia*. Given that either *arizonensis* flies from time to time up the canyon or *angustifascia* flies down, overlapping with resultant hybridization in this area is explicable. But how does one account for records of *doudoroffi* near the Mogollon Rim (vic. Payson, Gila County) or at Hannagan Meadows in the White Mts. of Greenlee County, where elevations vary between 6,000-8,000 feet? While it is generally known that the range of *arizonensis* includes the lower elevations of central and southeastern Arizona (Perkins and Perkins, in press), it is less well known that occasional records exist from higher elevations; e.g., the collection of the LACM houses two specimens taken at Strayhorse Camp, White Mts., Greenlee County, Arizona, on June 28, 1937, by Don Meadows—a mere 13 miles from the locale at which the LACM example of *doudoroffi* was taken. C. Ferris (J.L.S. "Season's Summary," 1970) also reported the two species' being sympatric at Pine, Gila County, Arizona (elv. 8,000 feet), on September 1, 1969—this locale is ca. 12 miles N.E. of *doudoroffi*'s type locale.

Although it is conjecture to speculate that *doudoroffi* is not an aberration but a hybrid, interspecific breeding experiments should be able to shed considerable light on this, as yet, unanswered question.



Fig. 2.—Top: *L. weidemeyerii angustifascia*, Kanabownits, Grand Canyon, Coconino Co., Arizona, 5.VIII.47 (LACM). Middle: *L. astyanax arizonensis* X *L. weidemeyerii angustifascia* = *doudoroffi* (?), Oak Creek Canyon, Coconino Co., Arizona, 1.VI.42 (AHF). Bottom: *L. astyanax arizonensis*, Madera Canyon, Santa Rita Mts., Santa Cruz Co., Arizona, 25.VIII.46 (LACM).

Fig. 3.—Lower surfaces of the specimens illustrated in Fig. 2.

All illustrations approximately $\times \frac{3}{4}$

ACKNOWLEDGMENTS

The authors are indebted to Dr. W. D. Field (United States National Museum) and Drs. C. L. Hogue, J. P. Donahue, and R. Snelling (Los Angeles County Museum of Natural History) for the generous loan of material, without which this study could not have been possible.

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A NEW SUBSPECIES OF
GONEPTERYX AMINTHA (PIERIDAE)

FROM YUNNAN, MAINLAND CHINA,
WITH COMPARATIVE NOTES

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MURAYAMA AND SHIMONOYA (1962) PUBLISHED a black and white figure without description of an unusual specimen of *Gonepteryx amintha* Blanchard. On request the first of these authors sent me the figured and one additional specimens for more detailed study. Visible characters and those resulting from the study of the wing pattern of these specimens by photography with ultraviolet light disclosed that these specimens belonged to a new, distinct taxon. These observations were later supported when in 1969 I received a large shipment on loan from the Staatliches Museum für Tierkunde in Dresden (D. D. R.), including seven male specimens of the same form from the same locality. All nine male specimens serve as the type-series of a new subspecies described below:

***Gonepteryx amintha murayamae* Nekrutenko, n. ssp.**

Male: Upperside of forewing a vivid orange color, more intense than in *G. a. amintha* and *G. a. formosana* Fruhstorfer, but rather approximating *G. a. thibetana* Nekrutenko. Discal spot small and hardly recognizable against ground color. Hindwing with orange-lemon ground color, bearing a prominent discal spot. The shape of the hindwing is rounded and slightly dentate (Fig. 1, bottom row).

Hidden wing pattern (Nekrutenko, 1964) characterized by a remarkable reduction of dark elements of both fore- and hindwings (Fig. 2, bottom row). Such a degree of dark element reduction within *G. amintha* is shown only by *G. a. thibetana*.

Length of forewing, base to tip: 29.0-31.6 mm.

Female: Unknown.



Fig. 1.—Subspecies of *Gonepteryx amintha*, upper surfaces. Top left: *G. a. amintha*, ♂, Kunkalashan, Szetschwan (Staatl. Samml. Bayern, Munich). Top center: *G. a. thibetana*, ♂, paratype, Lalung, Pachakshiri, S. E. Tibet, 6.v.1938, Ludlow and Sheriff leg. (Brit. Mus. (N. H.)). Top right: *G. a. formosana*, ♂, "Formosa" (Staatl. Mus. Tierk., Dresden). Central row: females of these subspecies. Bottom center: *G. a. murayamae*, ♂ holotype. Bottom left and right: *G. a. murayamae*, ♂ paratypes.

Holotype male: China mer. occ.: prov. Yunnan occ.: Weihsu, Mekong-Flüss, July (year unknown), 2500 m. (27°13'N, 99°16'E).

Holotype and six paratypes (same data) are deposited in the collection of the Staatliches Museum für Tierkunde, Dresden; 2 paratypes are in the collection of Shû-iti Murayama, Osaka, Japan. All are males.

Comparative notes: The chromaticity characteristics of four subspecies of *G. amintha* are given in Table I in CIE co-ordinates x , y and z for standard source of white light B. Colorimetric data were obtained microscopically by comparison of wing color with standard certified color samples for which spectrophotometric parameters are known. The dominant wavelength of reflected visible light and its purity (P) are shown along with the chromaticity data in Table I.

The new subspecies is remarkable for its extremely high degree of ultraviolet reflection. On the basis of increasingly great surface of reflection of ultraviolet light on the wings, the subspecies of *G. amintha* may be arranged into the following sequence: *amintha-formosana-thibetana-murayamae* (see Fig. 2). Comparison of this sequence with the chromaticity data on Table I shows a regularity common to all members of the genus *Gonepteryx*: the longer the dominant wavelength of reflected visible light, the larger are the ultraviolet reflecting areas. In other words, orange brimstone butterflies will always reflect more ultraviolet rays than will yellow or greenish ones.

The named subspecies of *G. amintha* (excluding the present one) are as follows:

- G. amintha amintha* Blanchard, 1871. *Compt.-rend. Acad. Sci. Paris*, 72 (25): 810 (Mou-pin, Thibet).
G. amintha formosana Fruhstorfer, 1908. *Entom. Zeits. Stuttgart*, 22 (25): 102 (Taihanriku, Formosa).
G. amintha limonia Mell, 1943. "Zoologica", *Orig. Abh. Gesammtgeb. Zool.*, 36 (100): 116 (Nordkuantung, Chekiang, China).
G. amintha meiyuana Murayama, 1962. *Tyô To Ga*, 13: 89 (Formosa).
G. amintha thibetana Nekrutenko, 1968. Phylogeny and geographical distribution of the genus *Gonepteryx*. Kiev, Naukova Dumka: 77 (Lalung, Pachakshiri, S. E. Tibet).

I am here giving a full translation (from Russian) of the original description of *G. a. thibetana* (Figs. 1 and 2, top center).



Fig. 2.—Hidden wing-patterns of specimens illustrated in Fig. 1 (right sides only).

CIE COLOR CO-ORDINATES OF FOUR SUBSPECIES OF GONEPTERYX AMINTHA

ssp.	x'	y'	z'	M	x	y	z	WL	P, %
amintha	70.0	67.6	15.2	152.80	0.4581	0.4424	0.0994	570	55
formosana	51.1	50.0	8.2	109.29	0.4675	0.4547	0.0479	576	85
thibetana	67.7	63.2	6.0	136.87	0.4946	0.4617	0.0436	578	75
murayamae	67.7	63.2	6.0	136.87	0.4946	0.4617	0.0436	578	75

Notes: 1. Color co-ordinates are given for the forewing.

2. Wavelength (WL) in millimicrons.

Male: Upper surface of forewing bright orange; toward the wing margins this color becomes lighter, especially between the veins, and approximates the color of the hindwing. Forewing bears a very small (less than 1 mm in diameter) orange discal spot that is almost invisible against the ground color. Costal margin of forewing is very bowed, forming a distinct, backward curved angle.

Hindwing above vivid yellow, as on both wings of *amintha amintha*, bearing a prominent orange discal spot of large size (2-3 mm). Shape of hindwing rounded, wavy: the margin bearing notable cuttings, though it is not dentate as in *G. mahaguru*.

Female: Fore- and hindwing are of similar light, greenish-yellow color. Forewing bears a small, and hindwing a large, orange discal spot; toward the margins the color becomes yellow, as in male hindwing. In shape of the wings the female does not differ from the male.

Expanse of wings: ♂ ♂ 50-60 mm, ♀ ♀ 60-65 mm.

The hidden wing pattern of the male is characterized by the narrow *zona opaca marginalis* of the forewing. The bright central spot of the hindwing is variable in size in different specimens: it may occupy nearly the entire surface with the exception of a narrow marginal band, or it may be restricted to only the central part of the wing. In females the hidden wing pattern is absent: on the dark ground tones are the bright discal spots.

Holotype male: S. E. Thibet, Lalung, Pachakshiri, 7000 ft., 6.v.1938, F. Ludlow and G. Sheriff leg. [British Museum (Natural History)].

Allotype female: same label data, 2.v.1938.

Paratypes: 4 ♂ ♂, 1 ♀, same data, 4-6.v.1938.

Material deposited in the collection of the British Museum (Natural History).

ACKNOWLEDGMENTS

My thanks are due to Prof. Dr. Shû-iti Murayama and to Dr. R. Krause, Keeper, Staatliches Museum für Tierkunde (Dresden) for loan of material for this paper, and to Dr. Lee D. Miller, who edited the manuscript.

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REDUCTION OF ABDOMINAL SCALES OF THE MONARCH BUTTERFLY IMAGO AS A RESULT OF CAUTERIZING THE Abd PPM OF THE PUPA

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IT HAS BEEN PREVIOUSLY DEMONSTRATED that if the LN PPM of the pupa of the monarch butterfly is cauterized the scales of the forewings of the imago exhibit marked reduction in pigmentation; if the MO PPM is cauterized there is a marked reduction in the number of scales on the head (Urquhart and Tang, 1970).

As a follow-up to the above experiments, the Abd PPM (Fig. 1), which PPM extends across the dorsal surface of the third abdominal segment, was cauterized for one half its total length—it was found that if the entire PPM was cauterized then the imago was unable to free the abdomen from the pupal exuvia.

The Abd PPM of 25 pupae were cauterized and of these, 7 indicated no discernible reduction in the number of abdominal scales (Fig. 3); 6 indicated a noticeable reduction on the 8th and 9th abdominal segments; and 5 indicated a marked reduction, particularly on the dorsal surface (Fig. 2). Seven imagoes failed to completely eclose owing to the adherence of the abdomen to the pupal exuvia.

Twenty-five specimens were used as controls in which areas remote from the Abd PPM, but still in the abdominal region, were cauterized and of these 18 eclosed with no discernible reduction in the number of abdominal scales; 7 failed to eclose.

ACKNOWLEDGMENT

This investigation, which is a small part of a study dealing with the ecology and physiology of *Danaus p. plexippus*, was made possible by grants to the University of Toronto from the National Geographic Society and the National Research Council of Canada.

The photographs were taken by David Harford, technician at Scarborough College.

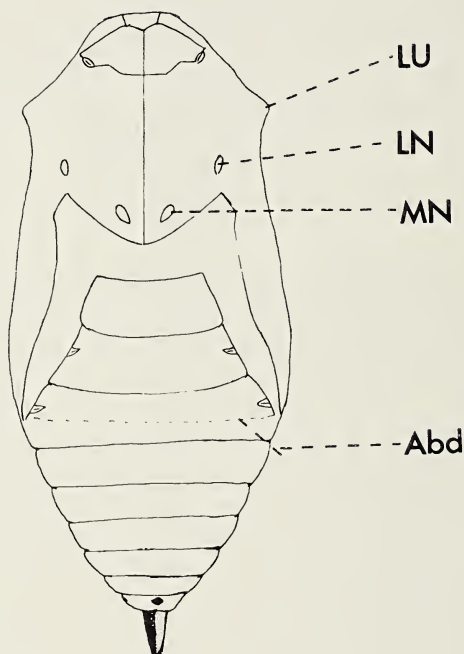


Fig. 1.—Dorsal aspect of the monarch butterfly pupa showing the position of the Abd PPM (see "literature cited" for designation of the other PPMs).

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Fig. 2.—Absence of scales on the dorsal surface of the abdomen as a result of cauterizing the Abd PPM. (Note: Abdominal shrinkage was not associated with this treatment—shrinkage, as in any dried specimen, exhibits marked variation.



Fig. 3.—Control specimen indicating no decrease in abdominal scales.

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SOME TECHNIQUES FOR THE REARING OF MEGATHYMUS LARVAE

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DURING THE PAST FIVE YEARS the authors have successfully reared to adults approximately 400 larvae of the genus *Megathymus*. About 75 of these larvae have been reared from very early instars. With the exception of four larvae of *Megathymus coloradensis navajo* Skinner, all of our rearings have been accomplished under controlled environmental conditions indoors. The rearing of such large numbers of larvae indoors has led us to adopt certain techniques whereby we would be assured of perfect adults and, at the same time, enable us to make observations on the behavior of the larvae.

All of the *Megathymus* larvae reared by us are borers in the caudices of various species of *Yucca*. Our rearings include the following *Megathymus* subspecies: *Megathymus coloradensis arizonae* Tinkham; *Megathymus coloradensis navajo* Skinner; two un-named populations of *Megathymus coloradensis*; *Megathymus ursus ursus* Poling, and *Megathymus ursus deserti* Wielgus, Wielgus and Wielgus. Each of the preceding subspecies has its own larval peculiarities, as well as similarities, and the species of *Yucca* involved will also suggest certain avenues of approach towards a successful rearing.

The greatest problem confronting the rearer of *Megathymus* larvae is the preservation of the foodplants in a wholesome condition throughout larval development. Loss of plant moisture, and the subsequent desiccation of the larvae, must be prevented or reduced over a time period which may approach six months in some subspecies. The basic problem does not change with feeding larvae, though, with later instars, the period involved for the retention of plant moisture is reduced.

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Fig. 1.—Inducing *Megathymus* larva to vacate burrow by prodding with a broom straw.

Megathymus larvae are collected *in situ* by removing the infested *Yucca* caudices from the ground. The caudices are placed in ordinary corrugated cardboard cartons in the field, labeled with significant collecting data, and are transported back to the laboratory with no further treatment enroute. Upon arrival at the laboratory, each section of *Yucca* caudex is prepared so as to retain vital pupal moisture and succulence. Ideally, the caudex should be prepared so as to remain viable throughout the larva's development but this is not always possible. We have used the following techniques successfully, but each technique used is determined subjectively, considering the *Yucca* species, the condition and size of the caudex removed, and the anticipated larval period.

No matter how long or short the larval feeding period, every section of the *Yucca* caudex is bagged in a polyethylene plastic bag which is tied, or taped, tightly to the upper end so as to prevent loss of moisture. Since there are so many variables involved, each technique presented herein is subject to some modification on an individual basis and we try to be as flexible and as innovative as the situation demands.

1. Caudices of *Yucca baccata* Torrey remain viable, and may take root, if first encased in damp pine sawdust or peat moss. We have also wrapped the caudices with ordinary newspapers soaked in tap water, then bagged with the plastic bags. Water is added as required. There is always the danger of rotting of the caudices with this technique.

2. If the larval period does not exceed four months, or if the caudex is medium-sized, wrapping with aluminum foil, then bagging in plastic, is a highly satisfactory treatment. The caudices remain in surprisingly good condition with this technique and are not prone to rotting. This is our preferred technique for the caudices of *Y. baccata* and *Yucca schottii* Engelman.

3. When the caudex is small and a larval transfer certain within a month's time, or if the caudex is very large, bagging only with the polyethylene plastic bag is sufficient. The disadvantage with this technique is the promotion of mold on the caudex.

In the rearing of *Megathymus* larvae, it is inevitable that some will have to be transferred to fresh, or larger, sections of caudices to complete their development. Two problems confront the rearer in such a situation: a) the safe removal of the larvae from the old caudices and, b) the establishment of the larvae

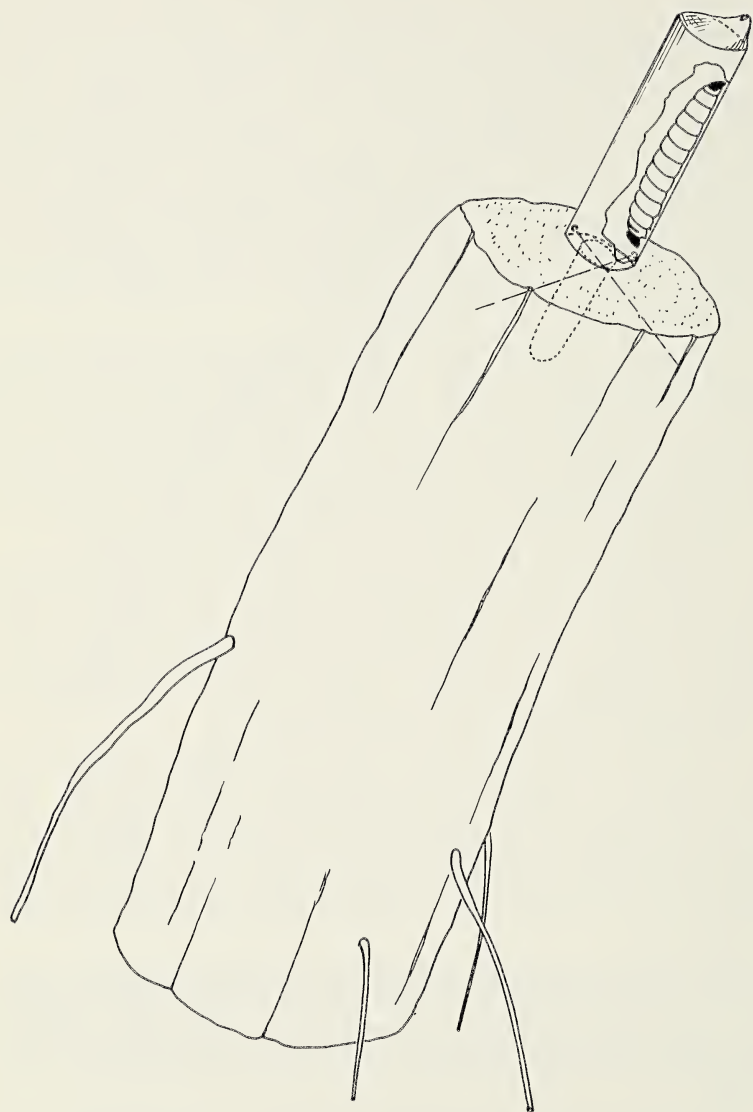


Fig. 2.—Transferred *Megathymus* larva established on fresh *Yucca* caudex by means of an artificial "tent" of rolled paper.

in the new caudices. Removal of a larva is initiated by exposing the burrow as close to the larva as possible without inflicting injury. In some cases, the caudex may disintegrate below the larva thereby making the removal process easier.

After the larva is exposed in the burrow, it is induced to vacate by gently prodding the far extremity with a broom straw. The straw is inserted between the larva and the burrow wall and a tickling motion is applied to the larva's extremity. This results in a gradual abandonment of the burrow by the larva. (See Fig. 1) Abandonment is accomplished even if the larva is reversed in the burrow provided that the broom straw tickles its far extremity.

The removed larva must now be re-established in the new caudex. Our first transfer attempts involved the larvae of *M. u. deserti* (Wielgus *et al.*, 1972) utilizing the vacated burrows of *M. c. navajo*. This technique was soon abandoned in favor of an artificial "tent" affixed to the fresh caudex. The artificial tent consists of a rolled tube of paper 2 inches long by 7/16 inch in diameter. A thin slice is taken out of the caudex, exposing the succulent pulp, and the paper tube is affixed over the slice using insect pins. The larva is introduced to the tube opening and allowed to make its way in. It will subsequently close the open tube end with silk, leaving a small hole for defecation, and proceed to bore slowly into the caudex. (See Fig. 2) With the larvae of *ursus*, the tubes are removed after about two weeks have elapsed.

All *Yucca* caudices containing larvae are stored in corrugated cardboard cartons labeled with collecting and rearing data. Those cartons containing larvae requiring chilling and a period of diapause are placed outdoors in shade at the necessary time; the larvae of *ursus* feed on through without diapausing.

Mature diapausing larvae (either reared or field-collected) ready for pupation are reintroduced to higher indoor temperatures while still in the caudices. Each pupa obtained is removed by pulling off the tent and inverting the caudex, thus allowing the pupa to drop out easily into one's open palm. The pupae are then stored in upright rolled paper tubes, 2 inches long by 7/16 inch in diameter, cemented to the inside bottom of corrugated cardboard cartons with sides three inches high. The tubes are spaced 2½ inches on center. The authors utilize cartons accommodating 24 tubes each. Each carton is labeled with corresponding significant data. Since *Megathymus* pupae are highly mobile, the open ends of the tubes are crimped

inwards slightly so as to prevent the pupae from working out. We are now introducing mature larvae directly into the paper tubes, thereby eliminating the problem of storage space for bulky caudices. So far, no problems have developed with this method and the larvae have pupated directly in the tubes.

At an indoor temperature of 75-80 degrees Fahrenheit, pupal duration varies from 21 to 26 days. Up to twenty adults may eclose on a single day. Since the senior author is engaged in a profession requiring his absence from the laboratory during a greater part of the day, a method had to be devised to keep the newly-eclosed adults inactive prior to killing. This was accomplished by covering the cartons with stiff sheets of black construction paper which allowed no light within. In total darkness, the adults will remain quiescent for several hours, which is sufficient for their disposal at the author's convenience.

Each adult is immobilized by pinching the thorax with forceps. It is then dropped into a paper drinking cup bearing data associated with it, including date of emergence, and killed by thorough freezing in the freezer compartment of a household refrigerator. Prior to spreading, each adult is defrosted as needed, care being exercised so as not to jar the paper cup containing the brittle, frozen specimen.

ACKNOWLEDGMENT

The authors are grateful to Dr. Frank F. Hasbrouck, Associate Professor of Zoology and Curator of Insects, Arizona State University, Tempe, Arizona, for critically reviewing the manuscript.

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CONCERNING

HELICONIUS CYDNO ABERRATION
"LARSENI" NIEPELT (NYMPHALIDAE)

AND ITS RELATION TO
HELICONIUS CYDNO BARINASSENSIS MASTERS

JOHN H. MASTERS

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NIEPELT (1916) DESCRIBED *Heliconius cydno* ab. "larseni" from a single male from Colombia. From his description and figure, his specimen is very close in appearance to *Heliconius cydno barinasensis* Masters (1972), described in a recent number of this journal. Niepelt's figure of "larseni" depicts a butterfly almost identical to *barinasensis* (figure 1) on the dorsal surface, except the white band on the hindwing is shifted to a position nearer the margin. In *barinasensis*, the black margin outside of the white band is as wide as the band itself; in the example of "larseni" it is only about half as wide as the white band. Another apparent distinction is that the white band extends into cell 2V in *barinasensis*, while in "larseni" it ends in cell Cu₂. The ventral hindwings are very distinct; *barinasensis* displaying a mirror image white band to that of the dorsal surface while "larseni" is immaculate of a white band with the ventral aspect almost identical to *Heliconius cydno perijaensis* Masters.

H. c. barinasensis was described from the Barinas slope of the Venezuelan Andes and there is a possibility that "larseni" could have also originated here, rather than Colombia, and represent an atypical example of the Barinas population. It seems more likely to me, however, that the true origin of "larseni" is the Magdalena region of Colombia.



Fig. 1.—*Heliconius cydno barinasensis* Masters, paratype male, 1000 meters, Barinitas to Santo Domingo Road, Barinas, Venezuela, 5 February 1968, leg: J. H. Masters. A: dorsal aspect. B: ventral aspect. Natural scale.

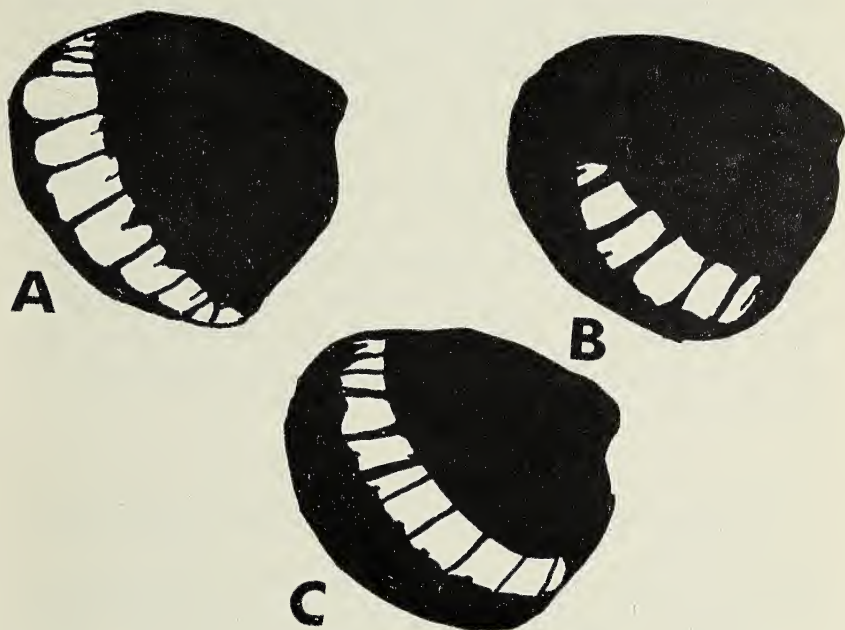


Fig. 2.—Representations of dorsal hindwing patterns of described forms of *Heliconius cydno*. A: *H. c. cydno* Doubleday & Hewitson. B: *H. c.* ab. "larseni" Niepelt. C: *H. c. barinasensis* Masters.

In either case, I don't consider "larseni" available for use as a species-group name under the provisions of the International Code of Zoological Nomenclature Adopted by the XV International Congress of Zoology. The Code (article 1; article 45 (d) (iii); and glossary: definition of the term infrasubspecific) provides that all names given to aberrations as such, transition forms as such, seasonal forms, wet and dry forms, color forms, sexual forms, generation forms as such, and similar forms are excluded from the species-group names and are unavailable. "Larseni" was clearly described as an aberrant individual.

To facilitate comparison, photographic figures of *H. c. barinensis* (figure 1) are hereby provided to relate to Niepelt's figure of "larseni". Black and white representations of the dorsal hindwings (figure 2), clearly show the distinctions discussed above.

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POLYMORPHISM IN TWO SPECIES OF ALASKAN *BOLORIA* (NYMPHALIDAE)¹ CLIFFORD D. FERRIS²

IN THE INTERIOR REGIONS OF Alaska, the early summer of 1971 was extremely warm and dry. These weather conditions produced higher-than-normal-density flights of many butterfly species. This situation coupled with the fact that odd-numbered years produce heavier flights of certain species in the interior, permitted extensive collecting and observation of butterfly fauna.

It was noted, for certain species, that in a large series collected in a given locality, considerable variation in individuals occurred; more so than is the case in related species. This phenomena was observed in two species of *Boloria*, which is the subject of this paper, and in several of the Satyridae including *Oeneis jutta* (Hübner), *Erebia youngi* Holland, and in a large series of *Erebia rossii* (Curtis) collected along the Denali Highway from five miles west of Paxon to McKinley National Park. Examination of this material makes one question the validity of some of the subspecific names which have been applied to Alaskan populations of certain butterflies.

The species of *Boloria* reported on are *Boloria polaris* (Boisduval) and *Boloria chariclea butleri* (Edwards). Although several subspecies of *chariclea* have been described from the Far North, if a subspecific name is to be applied to the interior Alaska race, *butleri* appears appropriate.

Figure 1 illustrates six specimens of *Boloria polaris* collected on the tundra (above timberline) just below Eagle Summit (3800') at mile 108.5 Steese Highway (approximately 110 miles N.E. of Fairbanks). Males are in the left column and females in the right column of the figure. The population at Eagle Summit

¹ Published with the approval of the Director, Wyoming Agricultural Experiment Station, as Journal Paper no. JA 504.

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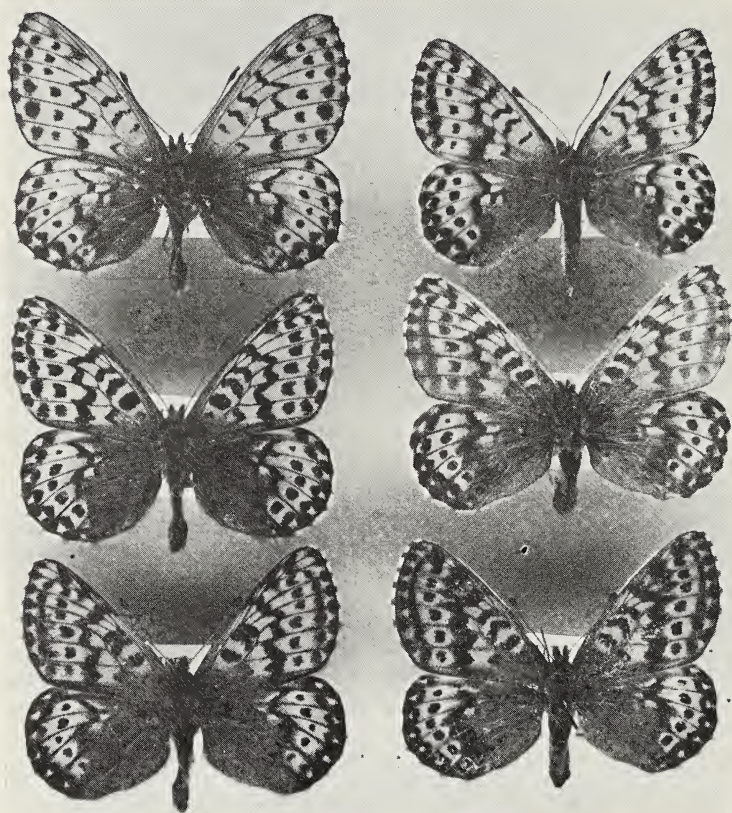


Fig. 1.—Variation in facies of *Boloria polaris* from Eagle Summit, Alaska.

is quite variable as the figure indicates. In general, the females are more heavily marked than the males and the general color of their wings is a deeper hue. In both sexes, maculation ranges from relatively light (almost penciling in some males) to quite heavy with general dark suffusion. The ground color of the males is essentially constant, while in the females it is rather variable. Some individuals tend toward a bluish or blue-green cast as in some of the females in the *Boloria napaea* (Hoffmansegg) races.

One-hundred specimens of *polaris* from various interior Alaska populations were examined in this study.

The variation in *Boloria chariclea* is even more pronounced than in *B. polaris* as is shown in Figure 2. Males are shown in the left column and at the bottom of the plate; females are in the right column. The specimens shown are all from a below-treeline meadow (2500') along the Denali Highway at the eastern edge of McKinley National Park. The variation among the females is considerable. Typical examples are shown in the figure. The specimen shown in the upper right of the plate is an extreme example of the pale end of the variation. It was also noted that many females exhibit an opalescent sheen dorsally. The male shown at the bottom of the plate is probably an aberrant as only one specimen was taken with these markings.

Eight-six specimens of *chariclea* from various interior Alaska populations comprised this study.

It is difficult to explain the variation in maculation shown by these two species. In the Rocky Mountains, we frequently see variation of this nature in *Boloria* and other Nymphalidae as a function of altitude. In this study, however, altitude is not a variable. The *polaris* and *chariclea* shown in the plates are from fixed locations. The variation in altitude among the other localities where these *Boloria* were collected is a matter of only a few hundred feet.

Thermal adaptation also comes to mind, but this normally leads to dark and hirsute examples in cold regions, and pale examples in warm regions (E. Bursell in M. Rockstein, 1964). Dark coloration leads to infrared absorption and pale coloration to infrared reflectance. In the populations studied, we have the full range of variation from a fixed locality.

Annual rainfall, which is a pattern factor in arid region and tropical genera, probably can be ruled out, as rainfall is fairly constant in Alaska from year-to-year, and presumably the two species studied are from the same larval year.

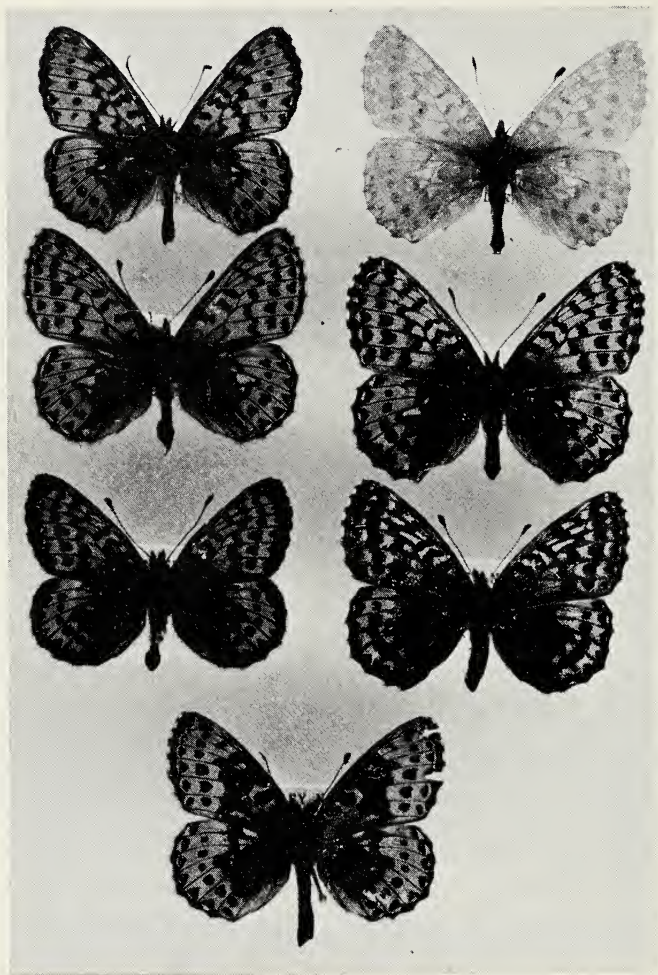


Fig. 2.—Variation in facies of *Boloria chariclea butleri* from the Alaska Range, Alaska.

Considerable temperature fluctuation does occur in the Alaskan interior and this is probably the cause of the observed variation. Melanic specimens and pattern deviations in butterflies frequently occur as a result of extreme temperature drops at the time of pupation. Thermal shock has been used by some collectors to produce pattern differences in reared specimens. In a one week period in June 1971, the author experienced air temperature changes from near 90° F to just above 32° F at constant altitude. During two days in the Alaska Range, snowfall occurred above treeline and rainfall below. The temperature drop was quite sudden (over the period of a few hours) as a storm front moved into the region. Since this type of sudden temperature change is common in the summer in the Far North, it may explain the variations in facies in given populations of certain species of butterflies. Since inclosion in butterflies takes place over a period of from 24 to 72 hours in many species, a severe temperature drop over a period of 8 hours might well affect the resultant imagoes. If this, in fact, is the cause of the observed pattern variation, then perhaps certain subspecific names should be re-evaluated. Many of the species from the Far North were described from one or a few specimens, as this was all of the material available at the time. Now that transportation into isolated regions is relatively easy, populations should be examined and nomenclature re-examined.

Some consideration was given to genetic factors and gene pools, but the author feels that these matters are probably not the major cause for the observed variability in the species examined. It is felt that genetic differences within a given population do play some role in the pattern deviations, but not the principal one.

ACKNOWLEDGMENT

The author would like to thank the park authorities, McKinley National Park for the issuance of a permit to collect specimens and to carry out studies in the Park.

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A NEW SPECIES OF *NEPHELODES* GUENEE
FROM THE GREAT BASIN AREA OF
NORTHEASTERN CALIFORNIA (NOCTUIDAE: HADENINAE).
JOHN S. BUCKETT

University of California
Davis, California

AN UNDESCRIBED SPECIES of *Nephelodes* Guenée has been in collections of western lepidoptera for a decade now, and herein is presented a description of that species. *Nephelodes adusta* J. S. Buckett, new species, occurs in the Great Basin region of northeastern California (Modoc and Lassen Counties), and is in the adult stage in late summer. In addition, photographs of adults, and the male and female genitalia of *N. adusta* are presented. The male genitalia and adult photographs of *N. demaculata* Barnes and McDunnough and *N. mendica* Barnes and Lindsey, the two most closely related species to *adusta*, are also presented.

Nothing is yet known concerning the immature stages of *N. adusta*, but Crumb (1956), states (concerning another species contained within this relatively small genus), namely *N. emmedonia* Cramer, "Prefers grasses and cereal crops, but has been reported as feeding on weeds and the buds and leaves of fruit trees." It is unlikely that *N. adusta* will prove to be of agricultural importance as a pest, but the plausibility of it feeding on grasses and/or weeds might be a good possibility.

***Nephelodes adusta* J. S. Buckett, new species**
(Figs. 1, 2, 7, 8, 13)

DESCRIPTION: Holotype male: Ground color of primaries tan. Head with vertex and frons clothed in tan simple hairs and scales; palpi with second and third segments possessing elongate simple hairs ventrally, terminal segment short, stubby; compound eyes with numerous elongate hairs; antennae with scape and pedicel clothed in shortish flattened tan scales, flagellomeres with medial portion biserrate, fasciculate, serrations becoming shorter terminally, dorsally clothed in off-white scales. Thorax dorsally with collar not noticeably differentiated from remainder of thoracic vestiture, tan in coloration; disc and tegulae composed of unicolorous tan elongate hairs and scales; ventral portion clothed in simple tan hairs; legs possessing



1



2

Fig. 1.—*Nephelodes adusta* J. S. Buckett, Holotype male. Inspection Station 6 mi. N. Alturas, Modoc Co., Calif., 8 Sept 1962.

Fig. 2.—*N. adusta*, allotype female. Locality same as fig. 1, 10 Sept. 1962.

elongate tan hairs on femora and tibiae, tibiae also possessing short tan scales; unguis moderately bifurcate; primaries dorsally tan; basal line wanting, or at best slightly represented; transverse anterior line hardly represented, defined by tan coloration basally, terminally defined by darker median area; median area darker than ground color, concolorous with thoracic vestiture; orbicular wanting; reniform hardly discernible from darker median area, of ground color; transverse posterior line defined



3



4

Fig. 3.—*Nephelodes demaculata* Barnes and McDunnough, male. Johnsville, Plumas Co., Calif., 9 Sept. 1961 (W. R. Bauer & J. S. Buckett).

Fig. 4.—*N. demaculata*, female. Same locality and collectors as preceding.

by line of demarcation between dark median area and lighter subterminal area; subterminal area tan; subterminal line wanting; terminal line represented at base of fringes as darker coloration than ground color; fringes of ground color; ventral surface of primaries tan; secondaries dorsally off-white, near tan in coloration; fringes whitish; ventral surface equivalent to dorsal surface. Abdomen dorsally with tan simple hairs both dorsally and ventrally. Greatest expanse of forewing 16 mm. Genitalia as in figs. 7 and 8.



5



6

Fig. 5.—*Nephelodes mendica* Barnes and Lindsey, male. Spring Creek, NW Baker, Baker Co., Oregon, 7 Sept. 1963 (W. R. Bauer & J. S. Buckett).

Fig. 6.—*N. mendica*, female. Oak Creek Canyon, 7 mi. N. Sedona, Cochise Co., Arizona, 6 Sept. 1961 (J. S. Buckett)

Female: As in male except antennae with flagellomeres setose-ciliate; secondaries dorsally brownish, ventrally as in male. Greatest expanse of forewing 18 mm. Genitalia as in fig. 13.

SPECIMENS EXAMINED: Holotype male: CALIFORNIA: Border Inspection Station, 6 mi. N Alturas, Modoc Co., 8 September 1962. Paratypes: 47 males, 2 females. 1 female, designated allotype, same locality



7



8

Fig. 7.—*Nephelodes adusta*, paratype male, genitalia minus aedeagus. 6 mi. N Alturas, Modoc Co., Calif., 3 Sept. 1962. (Bauer-Buckett slide no. 67F26-21B).

Fig. 8.—*N. adusta*, paratype male, aedeagus. Data same as fig. 7.

as holotype, 10 Sept. 1962, (UCD Lepidoptera slide no. 71C16-1); 1 male, same locality as holotype, 3 Sept. 1962, (Bauer-Buckett slide no. 67F26-21B); 1 male, Alturas, Modoc Co., 6 Sept. 1959 (W. E. Simonds); 42 males same locality as holotype, 30 August-8 Sept., 1962; 1 male, same locality as preceding, 24 Sept. 1964; 1 male, same locality as preceding, 4 Sept. 1964; 1 male same locality as preceding, 4 Sept. 1968; 1 male, 1 female, Susanville, Lassen Co., 4 Sept. 1969 (R. P. Allen).

There is considerable intraspecific variation in size of *N. adusta*, the greatest expanse of the forewing in the male varying from $\pm$ 16 mm to 18 mm. In addition, the ground color of the primaries varies from tan to a darker brown, but without any suggestion of reddish-brown coloration as in *N. demaculata*.

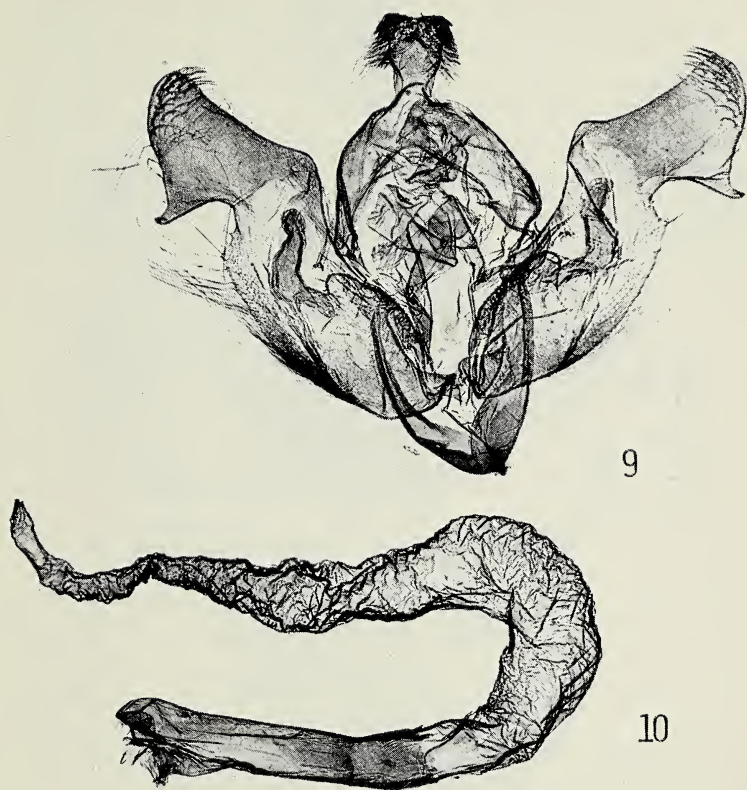


Fig. 9.—*Nephelodes demaculata* Barnes and McDunnough, male genitalia minus aedeagus. Johnsville, Plumas Co., Calif., 15 Aug. 1962 (Helena Pini), (Bauer-Buckett slide no. 67F26-22B).

Fig. 10.—*N. demaculata*, aedeagus. Data same as in fig. 9.

The ground color of the secondaries also varies, becoming darker in accordance with the primaries. Due to the paucity of females available for study, nothing is yet known concerning variation in this sex.

Nephelodes adusta can best be distinguished from *N. demaculata*, its closest relative, by its lighter maculation and lack of reddish-brown coloration of the primaries. The secondaries of

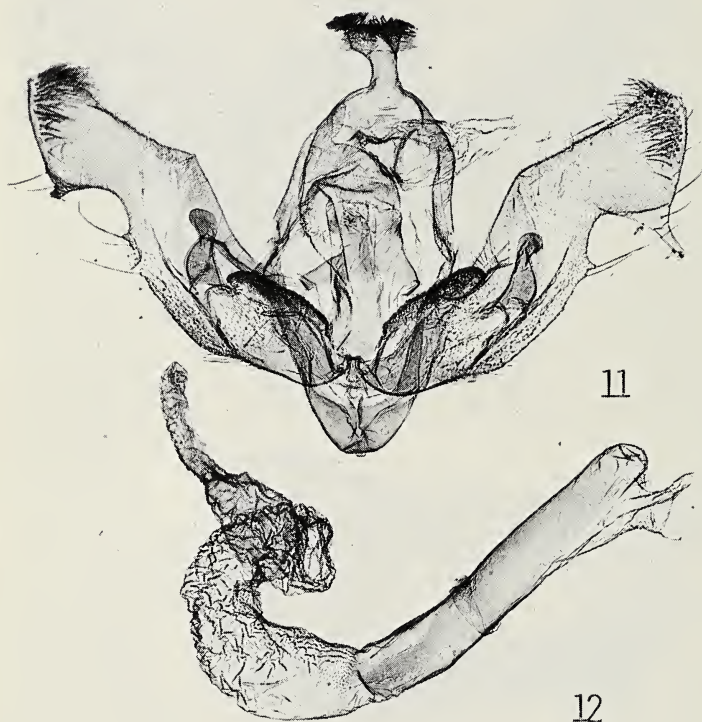


Fig. 11.—*Nephelodes mendica*, male genitalia minus aedeagus. Topaz Inspection Station, Mono Co., Calif., 17 Sept. 1967, (Bauer-Buckett slide no. 67L12-29).

Fig. 12.—*N. mendica*, aedeagus. Data same as in fig. 11.

N. adusta are not dark brown as in both male and female of *N. demaculata*. The male and female genitalia are distinct interspecifically between *N. adusta* and *N. demaculata*. In some respects, *N. adusta* is closely related to *N. mendica* Barnes and Lindsey, another inhabitant of terrain influenced by Great Basin flora. The coloration in both *N. adusta* and *N. mendica* is various shades of brown, but lacking the reddish-brown tinge



13

Fig. 13.—*Nephelodes adusta*, allotype female genitalia. 6 mi. N Alturas, Modoc Co., Calif., 10 Sept. 1962 (UCD Lepid. slide no. 71C16-1). Note the "squared-off" appearance of ovipositor lobes apically. In both *N. demaculata* and *N. mendica*, ovipositor lobes are more cleft centrally.

of *N. demaculata*. Also, *N. adusta* and *N. mendica* possess light colored secondaries in the male whereas *N. demaculata* possess dark brown secondaries.

Nephelodes demaculata Barnes and McDunnough

(Figs. 3, 4, 9, 10)

Nephelodes demaculata Barnes and McDunnough, 1918, Cont. Nat. Hist. Lepid. N. Amer. 4(2):97 + pl. 15, fig. 3; Draudt, 1923, Macrolepid. World, 7:153 + pl. 22, row c; McDunnough, 1938, Mem. So. Calif. Acad. Sci. 1:75.

N. demaculata is similar to *N. adusta*, but may be distinguished by possessing more reddish-brown coloration of the primaries and dark brown secondaries. *N. demaculata* occurs in moderately to more heavily forested areas of the northern Sierra Nevada Mountains of California. At present I have no records of this species from the Great Basin region.

The colored illustration in the Macrolepidoptera of the World (vol. 7, pl. 22, row c) is much too rosey-red; in actuality the color should be reddish-brown. In one-third of the specimens studied, the maculation of the primaries was easily discernible; whereas, two thirds of the specimens studied agreed with previously published literature in which maculation was said to be obscured.

Nephelodes mendica Barnes and Lindsey

(Figs. 5, 6, 11, 12)

Nephelodes mendica Barnes and Lindsey, 1921, Psyche 28:157-58; Draudt, 1923, Macrolepid. World, 7:153, McDunnough, 1938, Mem. So. Calif. Acad. Sci. 1:75.

N. mendica is somewhat similar to *N. adusta*, especially in that these two species, of the three herein concerned, possess whitish secondaries in the male sex (*N. tertialis* Smith, described from Manitoba, Canada, also does). *N. mendica* is darker brown in coloration than is *N. adusta*, and appears to be slightly larger.

N. mendica is rather widespread in the Great Basin region, occurring from Arizona north into Oregon and from eastern California east into Utah.

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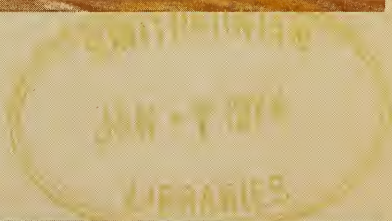
IN THIS ISSUE

Latitudinal gradients in species diversity of the new world swallowtail butterflies	Frank Slansky, Jr.	201
Lack of melanism in <i>Colias</i>	John H. Masters	218
A population study of <i>Euptychia hermes</i> in northern Florida	Thomas S. Kilduff	219
<i>Limenitis weidemeyerii angustifascia</i> X <i>L. astyanax arizonensis</i> = (?) ab. <i>doudoroffi</i> (Gunder) 1934.	E. M. Perkins, Jr. and John S. Garth	229
A new subspecies of <i>Gonepteryx amintha</i> (Pieridae) from Yunnan, mainland China.	Yuri P. Nekrutenko	235
Reduction of abdominal scales of the Monarch butterfly imago as a result of cauterizing the Abd PPM of the pupa.	F. A. Urquhart	241
Some techniques for the rearing of Megathymus larvae	Ronald S. and Dale Wielgus	245
Concerning <i>Heliconius cydno</i> aberration "larseni" Niepelt	John H. Masters	251
Polymorphism in two species of Alaskan <i>Boloria</i>	C. D. Ferris	255
A new species of <i>Nephelodes</i> Guenee from the Great Basin	John S. Buckett	260

1-24

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A NEW SPECIES OF PAPILIO FROM THE EASTERN UNITED STATES (PAPILIONIDAE)

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ABSTRACT

A new species *Papilio joanae* is described. The male and female types, a mature larva, and the male genitalia are figured. The type locality is Warsaw, Missouri in forested areas. This multivoltine species differs from its nearest relatives *Papilio polyxenes asterius* Stoll, 1782 and *Papilio bairdii* Edwards, (1867) in wing pattern characteristics and differences in color and pattern of the larvae. The presently known range is restricted to forested areas in the Missouri Ozarks. The larvae feed on wild species of APIACEAE. The male and female types have been deposited in the American Museum of Natural History.

INTRODUCTION

SINCE 1962 A POPULATION has been studied of a *Papilio* species occurring in the thickly forested areas of the Missouri Ozarks. In general appearance the adults resemble *Papilio polyxenes asterius* Stoll, 1782. Because of behavioral and habitat differences exhibited by the adults, a number of genitalic preparations were made of both sexes to see if any differences were apparent between the forest populations and the open field and garden species *asterius*. Individual variation was found in both species but only vague structural differences by which the open field and forest populations could be separated. In a way this was to be expected since Rothschild and Jordan (1906) could find no recognizable differences in the genital armature of members of the *machaon* group with the exception of *Papilio indra* Reakirt, 1866. Several attempts were made over the years to rear specimens of the forest populations but without success. Females taken and confined with the favorite *asterius* foodplants of the area (carrot, dill, parsnips, and wild carrot) refused to lay on any of these plants although *asterius* females will almost always

oviposit freely on them. Finally, in June 1972 two small parasitized *Papilio* larvae were found on a plant later identified as *Taenidia integerrima* (L) Drude (APIACEAE). This plant gives off a strong pungent odor when brushed or handled roughly. No other females were collected in 1972 but on 29 April 1973 a female was taken near Warsaw, Missouri and when confined over this plant oviposited freely; a fine series of adults emerged in early June. *T. integerrima* dries up by late July but in early August 1973 ova and larvae in all instars were found on another woodland APIACEAE species *Thaspium barbinode* (Michx.) meadow parsnip. The larvae, especially in the final instar, are distinctive when compared with *asterius* larvae. A forthcoming paper will describe the life history in detail. With this large series of specimens for study, consistent pattern differences soon became apparent between this species and *asterius*.

Twelve names, all considered to be infrasubspecific, are currently associated with *P.p. asterius*. *P. asterius* var. *ampliata* Ménétriés, 1857 is a very dark form described from Mexico which has the inner row of spots obsolete in both sexes. It is a fairly common form in some Texas populations of *asterius* but is rare further north. *P. calverleyi* Grote, 1864 is an aberrant form with greatly expanded yellow areas on both wings. It occurs in both sexes. *P. asterioides* Reakirt, 1866 is another very dark form described from Mexico and probably synonymous with *ampliata*. *P. asterius* var. *alunata* Skinner and Aaron, 1889 is a female form which has the submarginal spots nearly absent. *P. asterius* var. pupae *viridis* Cockerell, 1889 was a name proposed for the green pupal form of *asterius*. *P. asterius* var. *semi-alba* Ehrmann, 1900 is an aberrant male form with forewing markings white instead of yellow. *P. polyxenes* var. *curvifascia* Skinner, 1902 usually lacks the discal cell spot of the hindwings. The yellow bands of the dorsal surface are large in both sexes. It was described from New Mexico but the name has been frequently applied to eastern *asterius* males which lack the discal cell spot on the hindwings. *P. asterius* ab. *ehrmanni* Ehrmann, 1925 is a male aberration with greatly reduced markings resembling the normal female pattern. *P. asterius* ab. *streckeri* Holland, 1927 is a common female form in which the cell spot of the hindwings is missing on the ventral surface. *P. polyxenes* ab. *forsythae* Wood, 1937 is a form with the

yellow bands much wider than normal *asterius*. *P. ajax* form *pseudoamericus* Brown, 1942 is a male aberration with yellow bands extending inward to the base of the hindwings. *P. polyxenes asterius* form *subamplicata* Dufrane, 1946 is a female form with yellow spots of the medial band missing on the hindwings. This form is not uncommon in late summer broods of *asterius*. An examination of original descriptions, type photographs, or types where possible has shown that none of these names can be applied to this new species which is now described.

***Papilio joanae* J. R. Heitzman, new species**

MALE: Dorsal surface: Ground color charcoal black. Forewing with a narrow yellow dash between veins along the outer margin. There is a row of rounded submarginal spots with the spot in cell CU2 very small. There is another row of larger yellow postmedian spots with basally tapering inner edges; the spot at the inner margin is reduced in size or nearly absent; the apical spot in this band is short and does not taper basally. Occasionally there is a faint yellow subapical spot and a faint yellow bar at the outer edge of the cell. Hindwings with marginal dashes slightly wider than those of the forewings. Submarginal yellow spots larger and slightly crescent shaped. The postmedial band of yellow spots is composed of various sized spots, mostly crescent shaped and slightly tapered basally. The cell area usually has only a faint trace of a yellow spot. Between the submarginal and postmedial spot bands there is a complete row of bright, powder blue spots; the one above the anal eye spot crescent shaped; the eye spot at the anal angle encloses a black pupil which in most cases connects with the inner or anal margin or both; color above pupil burnt orange, below pupil bright yellow. Tails black. Head black with two small yellow dots on the dorsal surface. Antennae black. Palpi black with white base. Thorax black; patagia black with a very faint yellow edging. Abdomen black with two rows of small yellow spots along each side; ventral surface of abdomen with two partial rows of small yellow spots. Legs and ventral surface of thorax and abdomen black.

Ventral surface: Pattern of the dorsal surface repeated but with the postmedial yellow bands of both fore and hindwings replaced almost entirely by orange. The submarginal bands of yellow spots are also partially replaced with orange. The band of blue spots is concentrated into small bright spots near the outer edge of the postmedial band; beyond the blue spots there is a scattering of

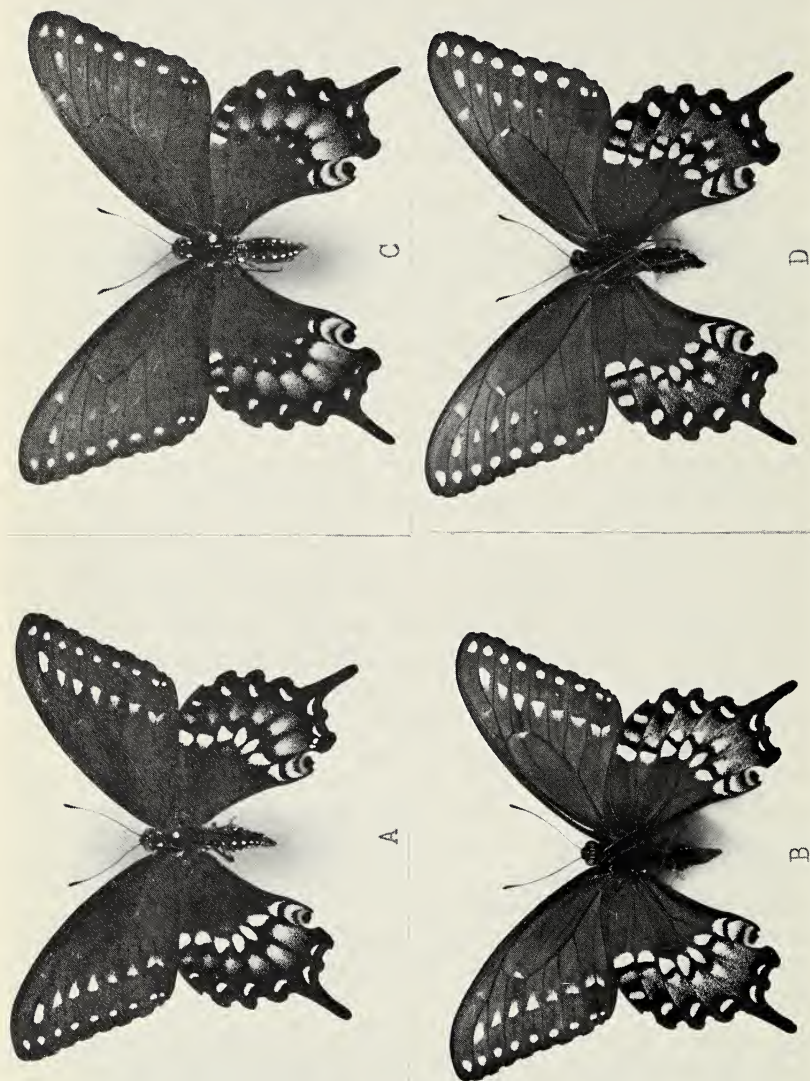


Fig. 1. (A) *Papilio joanae*, new species, holotype male, Warsaw, Missouri, 10 June, 1973 (J. R. Heitzman) X 2/3.

(B) Underside of holotype.

(C) Allotype, female, same data as holotype. X 2/3.

(D) Underside of allotype.

blue scales covering the area occupied by the blue spots of the dorsal surface.

FEMALE: Like the male but with the yellow bands reduced in size, especially the postmedial bands which are frequently nearly absent on both fore and hindwings above. The blue spot bands of the hindwings are enlarged. The anal eyespot has more orange than yellow. The postmedian spot bands on the ventral surface are usually entirely orange.

FOREWING LENGTH OF TYPE SERIES: Spring brood: Average for 43 males 38.7 mm, range 35.5–43.0 mm; for 15 females 41.6 mm, range 39.0–46.0 mm. Summer broods: Average for 80 males 46.6 mm, range 43.0–50.0; for 51 females 50.4 mm, range 44.0–54.5 mm.

GENITALIA: The genitalia of both sexes show a wide range of individual variation but the only fairly constant difference as compared to *asterius* seems to be a slightly different configuration of the valves. The genitalia alone cannot be relied upon for determining this species.

TYPES: Holotype, male, Warsaw, Benton County, Missouri, Elevation 800-880 feet, 10 June 1973 (J. Richard Heitzman); allotype female, same data as holotype; paratypes; imagines, 128 males and 68 females; larvae, 18 specimens; pupae, 3 specimens. Data as follows; eight males and one female, 25 April 1961; four males, 26 April 1962; one male 1 July 1962; one male, 13 August 1962; one male, 7 April 1963; six males, 14 April 1963; two females, 1 May 1963; seven males, 20 April 1965; one male and one female, 20 April 1969; four males and one female, 26 April 1970; four males and two females, 3 May 1970; eight males and four females, 23 April 1971; one female, 23 April 1972; one male and two females, 29 May 1971; one male, 25 May 1971; one male 27 May 1971 (J. Richard, Roger, Robert, Joanie, and Brenda Heitzman); one female, 29 April 1973; two males and one female, 10 June 1973; one female, 15 July 1973; nine males and two females, 8 August 1973; three males and one female, 14 August 1973; one male, 2 September 1973 (J. Richard Heitzman); one male and one female, 23 April 1972; one male, 10 August 1973; three males and one female, 11 August 1973 (Richard S. Funk); ex ova from female taken 29 April 1973; two males, 31 May 1973; seven males and three females, 1 June 1973; five males and three females, 2 June 1973; eight males and five females, 3 June 1973; nine males and three females, 4 June 1973; eight males and two females, 5 June

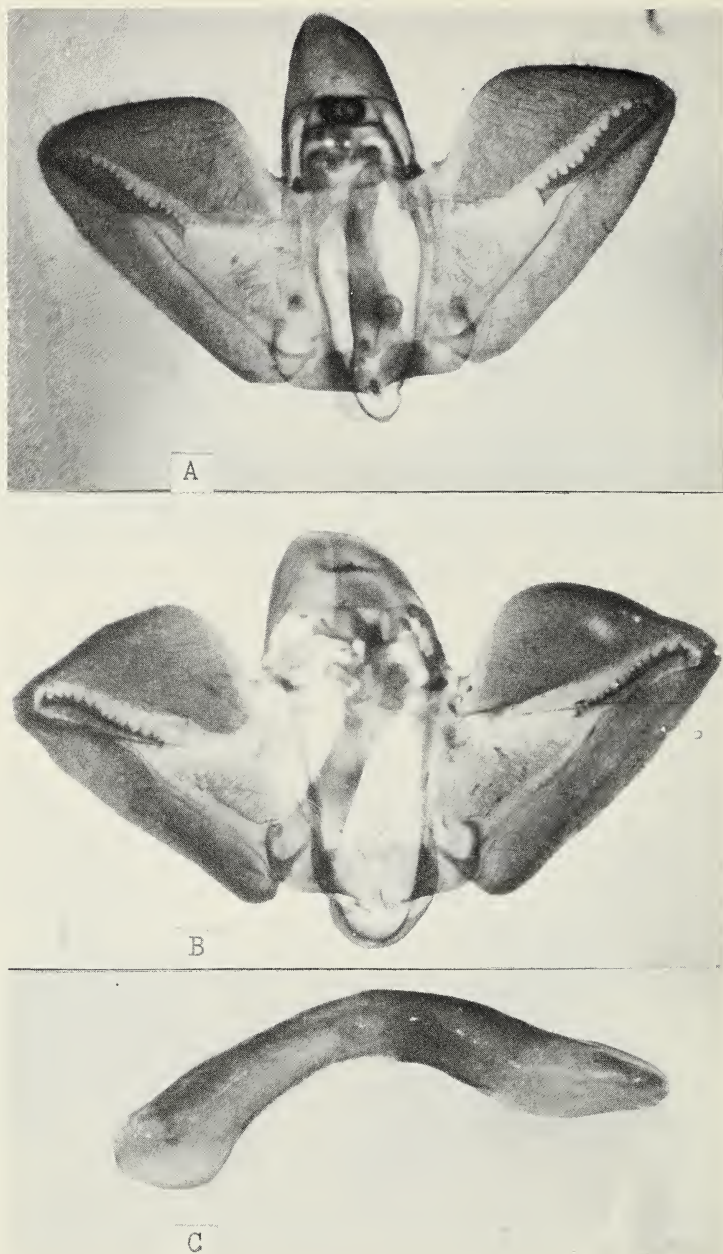


Fig. 2 Male genitalia. (A) *Papilio p. asterius*, Warsaw, Missouri, ventral view.

(B) *Papilio joanae*, new species, holotype, ventral view.

(C) Ventrolateral view of aedeagus of holotype.

1973; seven males and six females, 6 June 1973; two females, 9 June 1973; one female, 11 June 1973; one first instar, one second instar, one third instar, one fourth instar, and four fifth instar larvae; three pupae; ex ova from female taken 15 July 1973; one male, 11 August 1973; one male, 12 August 1973; one male and one female, 13 August 1973; five males, 14 August 1973; one female, 15 August 1973; two females, 16 August 1973; ex larvae collected 14 August 1973; one female, 27 August 1973; one male and one female, 28 August 1973; three males, 29 August 1973; two males and one female, 30 August 1973; two males and two females, 31 August 1973; 1 male, 1 September 1973; five males and six females, 2 September 1973; one female, 3 September 1973; three males and one female, 4 September 1973; one female, 5 September 1973; one fourth instar and eleven fifth instar larvae collected 14 August 1973. All paratype specimens from Warsaw, Benton County, Missouri.

TYPE LOCALITY: Warsaw, Benton County, Missouri, elevation 800-880 feet, in forest area.

In addition to the type series specimens have been examined from localities in Camden, Carter, Franklin, Johnson, Knox, Maries, St. Louis, and Washington Counties in Missouri.

LOCATION OF TYPES: The holotype and allotype will be deposited in the type collection of the American Museum of Natural History. Paratypes will go to the following institutions and individuals: The Florida State Collection of Arthropods, Gainesville, Florida; The Entomology Museum of the University of Missouri, Columbia, Missouri; Richard S. Funk, Southern Illinois University, Edwardsville, Illinois; Dr. Cyril F. dos Passos, Mendham, New Jersey; Dr. Alexander B. Klots, Putnam, Connecticut; Dr. Herman Flaschka, Georgia Tech University, Atlanta, Georgia; and the Heitzman collections, Independence, Missouri.

ETYMOLOGY: I take pleasure in naming this species for my wife Joanie Heitzman who for over 20 years has answered with a smile all the idiocrasies of a Lepidopterist husband.

DISCUSSION

The nearest allies of *Papilio joanae* are *asterius* and *P. bairdii* Edwards (1867). The males of *joanae* are much darker than *bairdii* males; most female *bairdii* are as dark as *joanae* on the dorsal surface but much lighter on the undersides. From *asterius*, *joanae* can best be told by the habitat where they occur, differences in the larvae, and



A



B

Fig. 3. Final instar larvae. (A) *Papilio joanae*, new species, paratype
(B) *Papilio p. asterius*, normal color form, from Warsaw, Missouri.

adult pattern characteristics as follows. Males: dorsal surface; the apical spot of the postmedial yellow spot band is single and fairly short, on *asterius* it is usually longer and or broken into two spots. The submarginal yellow spots of *joanae* are usually round while on *asterius* the lower spots are frequently oblong. The blue spot band on the hindwings of *joanae* is complete while on *asterius* there are usually only a few blue spots in the anal area of all but the spring brood. The anal eyespot of most *asterius* has a black central pupil, on most specimens of *joanae* this pupil will touch the inner or anal margin of the wing. Females: On *joanae* females the costal spot of the postmedial band of the hindwings above is small and obscured while on *asterius* it is usually rather prominent. In both sexes the postmedial bands of the ventral surfaces normally have more orange than those of *asterius*; the fifth spot from the costal margin of the postmedial bands of the hindwings are often no longer than spot four while on *asterius* the fifth spot is frequently twice as long as the fourth spot.

P. p. asterius occurs within the type locality of *P. joanae* but is confined to the road edges where flourishing colonies exist on an abundant growth of wild carrot (*Daucus carota*). Adult males of the two species seemingly ignore one another when coming in contact while actively engaging members of their own species.

ACKNOWLEDGMENTS

I am grateful to Richard S. Funk for his help over the last three years in locating new colonies of *P. joanae* and obtaining living material for this study. Dr. Warren Wagner has given valuable field assistance and determined associated flora. Dr. Cyril F. dos Passos has given helpful criticism regarding the manuscript and helped in obtaining several of the original descriptions and making translations where necessary. Dr Alexander B. Klots has given helpful suggestions regarding the manuscript. The Missouri State Park Board has kindly furnished collecting permits for the Missouri State Parks. Dr. Wilbur Enns has made available for study all the specimens contained in the Missouri University Collection. Last but by no means least I am indebted to my wife Joanie, my sons Roger and Robert, and my daughter Brenda for untold hours in the field locating and procuring specimens and searching for larvae and host plants.

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SPECIFIC ENTITIES OF THE SUBGENUS *ICARICIA* NABOKOV (LYCAENIDAE)

J. W. TILDEN

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ICARICIA WAS PROPOSED by Nabokov in 1945 with *Lycaena icarioides* Boisduval as the type. It is currently treated as a subgenus of *Plebejus* Kluk 1802. Of the names included under *Icaricia*, there has been some difference of opinion as to which should be treated as full species and which should be given less than specific status. The purpose of this paper is to give one point of view on this problem.

In arriving at the following conclusions, information derived from examination of male genitalia, color and markings of the adults, distribution, phenology, sympatry and food plant choices have been taken into consideration.

This study was begun some time ago, and there has been a free exchange of ideas with a number of other workers, most especially with Dr. Harry K. Clench and Mr. Carll Goodpasture. There are certain populations that seem to merit recognition at the subspecific level, which so far have remained unnamed. The naming of these populations is left to Dr. Clench.

The findings of the author and of Dr. Clench are in general agreement, differing only in minor details. However, the author takes sole responsibility for the opinions stated in this paper, which is being presented at this time to reinforce certain other forthcoming work.

All of the members of the subgenus *Icaricia* have male genitalia of a similar type. Certain members of the genus *Philotes* resemble members of *Icaricia* quite closely. In addition to distinctively different male genitalia, these members of *Philotes* have checkered fringes, and lack metallic scales in the aurora. Members of *Icaricia* all have plain unchecked fringes, and with the exception of *icarioides*, have metallic scales in the aurora on the under side of the hind wings.

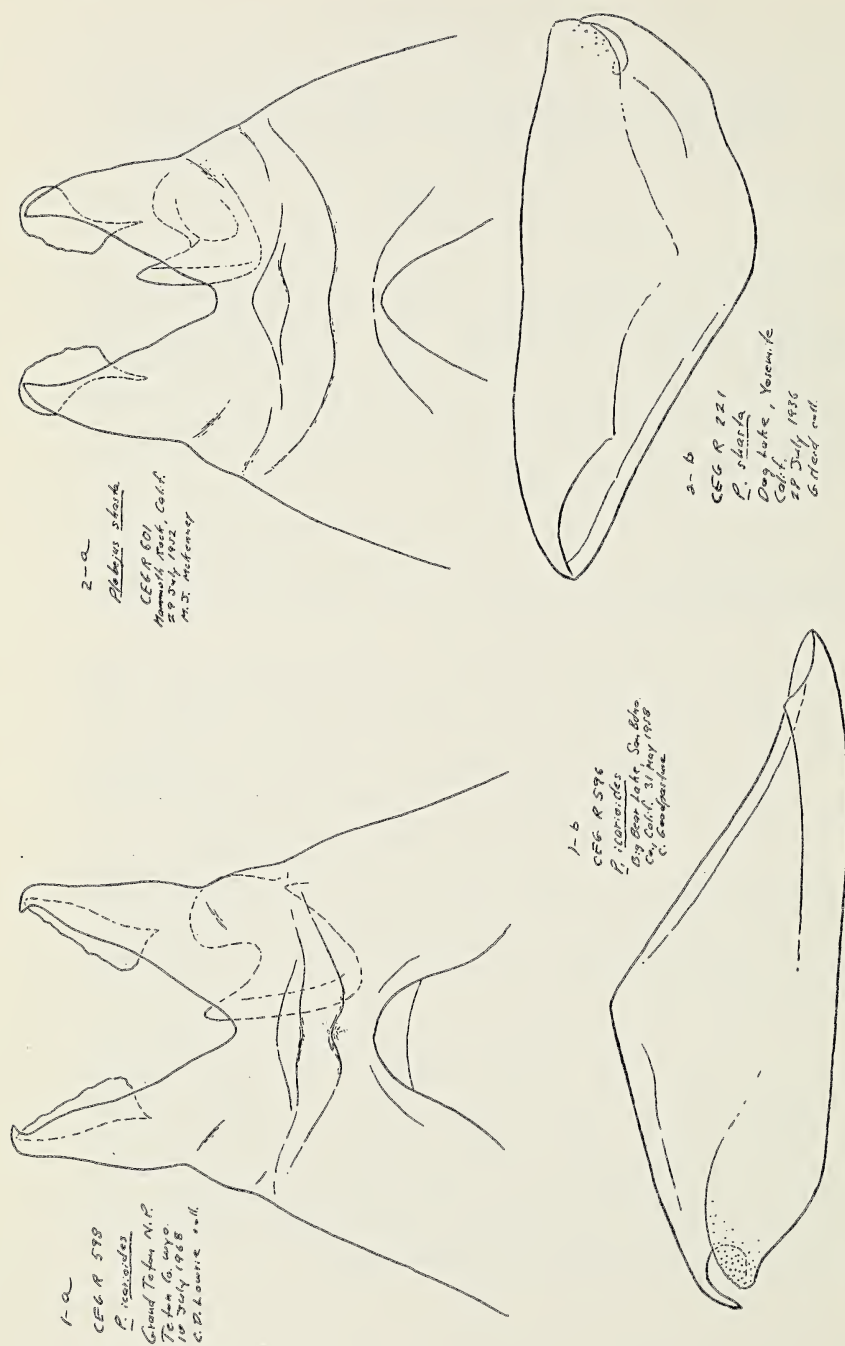


Fig. 1.—Male genitalia, *P. icartoides* Bdv. (a) dorsal view of uncus and left falx, (b) inner face of left valve.

Fig. 2.—Male genitalia, *P. shasta* Edw. (a) and (b) as in Fig. 1.

As considered here, the subgenus consists of five species. Each is considered below.

***Plebejus (Icaricia) icarioides* (Boisduval) 1852**

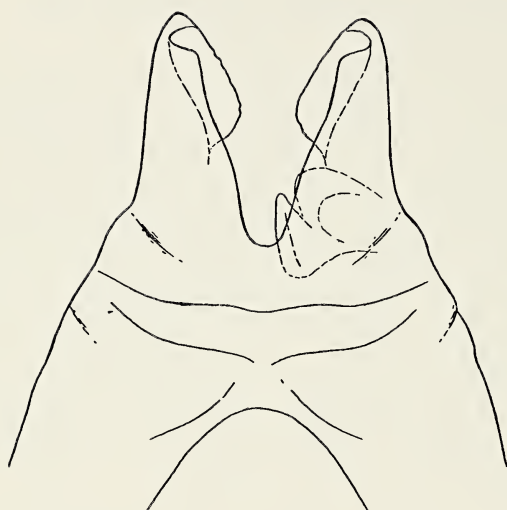
Ann. Soc. ent. France (2) 10:297 (TL "California")

This, the type of the subgenus, differs most in appearance from the other species associated with it. It is the largest in alar expanse and the least ornamented in its markings. It has a wide range in western North America, and is tolerant of both latitude and elevation. Suitable food plants for *icarioides* are unevenly distributed, which may account at least in part for the somewhat colonial habits of this species, which has developed a large number of relatively isolated populations. Many of these populations have evolved more or less distinctive differences in appearance. A number of these populations have received names, which are currently considered either synonyms or as valid at the subspecific level. For a continuing analysis of the variation of *Plebejus icarioides*, the reader is referred to the papers of Dr. John C. Downey.

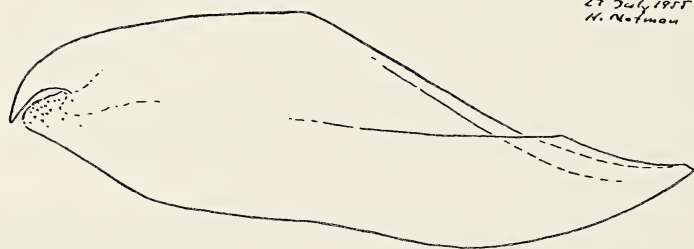
All populations of *icarioides* agree in having the males of some more or less uniform shade of blue above, nearly unmarked. The forewing cell bar is faint to slightly evident. The veins appear slightly lighter than the ground color. The borders are moderate to narrow, a bit wider on the forewing. The position of the aurora may be indicated by some small dark dots. UNF, the cell bar and post median spots are well developed. The markings of the hind wing below differ greatly from population to population and together with the ground color, form one of the prime characters by which the populations differ in appearance. Females may be entirely dark above, or more or less blue, depending on the population. The cell-end bars are often evident and the aurora may be indicated by a few light scales.

Male genitalia: the uncus lobes are pointed and dentate at the tips, and separated by a wide cleft. The terminal lobe (forearm) of the falx is both longer and wider than the basal lobe. The valve is long and narrow, tapering to the point of attachment. The inner rolled edge (sacculus) is relatively narrow. (Figs. 1-a, 1-b).

There seems to be no good reason for regarding *pardalis* Behr, 1867, and *pheres* Boisduval, 1852, as species distinct from



3-a
Phobocera acmon
 CEG R 577
 Monticello Dam, Yolo Co.
 Calif. 29 April, 1970
 C. Goodpasture



3-b
 CEG R 322 *P. acmon*
 Topanga, L. A. Co. Calif.
 27 July, 1955
 H. Notman

Fig. 3.—Male genitalia, *P. acmon* West. and Hew. (a) and (b) as in Fig. 1.

icarioides. *Pardalis* represents an unusually heavily marked population (TL, "Contra Costa Coast Range, in the vicinity of San Antonio," near the present Lake Merritt). *Pheres* Boisduval was an exceptionally lightly marked population, formerly found in the sand dunes of San Francisco, now apparently extinct. Somewhat similar appearing populations found in Marin County are by no means identical, and in my estimation should not be referred to as *pheres*.

Food plants of *icarioides* are various Lupines (*Lupinus* spp.), apparently only perennial species, and not all of these. In the San Francisco Bay region, *Lupinus chamissonis* is often selected. *P. icarioides* seems to be univoltine throughout its range.

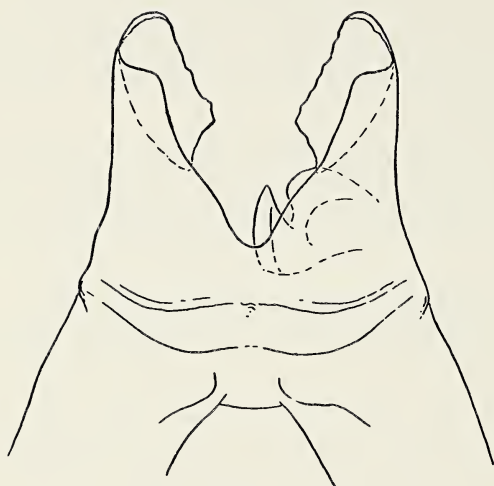
Plebejus (Icaricia) shasta (Edwards) 1862

Proc. Acad. Nat. Sci. Philad. 224:1862. (TL, "California," restricted by F. M. Brown (1970, 402-403) to the southwest side of Sheppard Pass, Tulare Co., Calif.).

A small species, the males duller blue above than their congeners, the dark borders unusually wide and grading into the ground color. The cell-end bars are evident on both pairs of wings. UNH, the aurora is of metallic spangles only, nearly or quite without red or orange. The females bear a general resemblance to the males except for duller coloration.

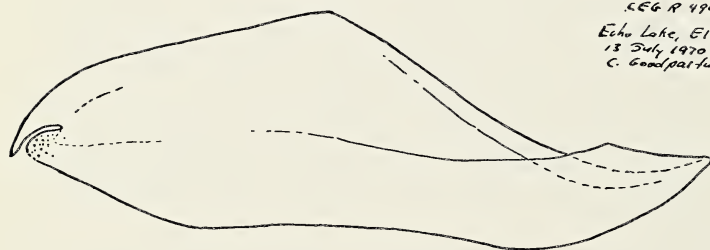
Male genitalia: The uncus lobes are not pointed but end as do those of all the species except *icarioides*, each in a quadrate-concave inward-facing structure. In *shasta* this is short and wide. The uncus lobes are separated by a wide and relatively shallow cleft. The forearm of the falx is longer than the basal lobe, and is somewhat pointed distally. The valve is broader than that of the other members of the group, a character which alone will usually identify the species. It is, however, subject to variation, and occasional individuals will be found that have the valve much narrower than the norm. (Figs. 2-a, 2-b).

Over much of its range *shasta* is a high-montane species. However, in the Sierra Nevada of California and in the Cascades of California and Oregon, there are localities where *shasta* occurs at intermediate elevations. Specimens from these lower elevations do not seem to differ markedly from those of higher elevations. Material from the very highest localities in the Rocky Mountains is distinctively dull and dwarfed, and represents *P. (I.) browni* Ferris 1970, (= *minnehaha* auct., not Scudder 1775). The name *comstocki* Fox 1925, based on



4-a
CEG R 479

P. lupini
Echo Lake, El Dorado Co.
Calif. 13 July 1970
C. Goodpasture



4-b
CEG R 484 P. lupini
Echo Lake, El Dorado Co. Calif.
13 July 1970
C. Goodpasture

Fig. 4.—Male genitalia, *P. lupini* Bdv. (a) and (b) as in Fig. 1.

material from Glacier Point, Yosemite National Park, Calif., was given to a phenotype in which the white scaling of the underside is greatly reduced or absent. Normal white-scaled individuals occur both north and south of the type locality of *comstocki*. In fact, individuals with reduced white scaling can be selected from almost any series of nominate *shasta*.

The food plant was until recently unknown, in spite of the relative abundance of the species. Recently observed to oviposit on *Trifolium* (Clover) by Oakley Shields in California, and by James Scott in Colorado. To date, the details of their observations have not appeared in print. *P. shasta* is apparently univoltine throughout its range.

Plebejus (Icaricia) acmon (Westwood & Hewiston) 1852

Gen. diurn. Lep., pl. 76, + p. 494, no. 139. (TL "California").

A small species, the males usually pale blue above with a pinkish aurora which is overlaid with the same iridescence as the rest of the surface. The veins are concolorous, the borders narrow, the end-cell bar usually absent. Females are often brown with conspicuous orange aurora, the borders not contrasting with the dark ground color. But more or less blue females occur, often in the same population with dark ones.

Male genitalia: Terminal quadrate part of uncus lobes short and narrow, and separated by a deep, narrow cleft. The forearm of the falx is much shorter than the basal lobe. The valve is less slender and tapering than that of *icarioides*, less broad than that of *shasta*. (Figs. 3-a, 3-b).

P. acmon is widely distributed in western North America and is found over a wide range of climatic conditions. It is multivoltine at lower elevations. The number of broods per year seems to depend on the length of a suitable reproductive season. Whether it may be single-brooded at high elevations is not known, at least partly because of confusion with the following species.

The known food plants are several and include *Lotus* (*Hosackia*, *Acmispon*) and *Astragalus*. Other legumes such as *Trifolium*, *Medicago* (Bur Clover, Alfalfa), *Melilotus alba* (Sweet Clover) and *Lupinus* have been reported or suggested. *Acmon* is also known to feed on certain species of *Eriogonum*, including the *E. latifolium* and *E. fasciculatum* complexes.

P. acmon and the next species, *P. lupini*, are widely sympatric. *P. lupini* occurs in some lowland localities where it

was previously thought that only *P. acmon* occurred. And conversely, it appears that *P. acmon* occurs at high elevations in some places where only *P. lupini* was previously believed to exist. Whether *cottlei* Skinner 1902 (TL San Francisco, Calif.) and *lutzi* dos Passos (TL Snowslide Canyon, 8 miles from Montpelier, Idaho), should be associated with *acmon* or with *lupini* may depend ultimately on a genitalic examination of the type material.

Plebejus (Icaricia) lupini (Boisduval) 1852

Ann. Soc. ent. Belg. 12: (TL "California....").

Usually larger than *acmon*, except the high-montane and northern populations of the two species may approach one another in size. Males, purplish-blue above, the dark borders wide and grading into the ground color. The veins may be slightly darker than the ground color and the end-cell bar of the forewings is often evident. The dark border is usually edged inwardly by light scales, giving a light "echo" or "phantom edge" internal to the dark border. This seems to be a distinctive character in this species. The aurora is orange-red and often formed of crescentic markings that cap the black spots. The females may be either blue or brown and have the aurora very prominent.

Male genitalia: The uncus lobes are flaring, the terminal quadrate areas much longer than wide. The cleft is wide and shallow. There are also minor but apparently constant differences in the falces and the valves. (Fig. 4-a, 4-b).

The food plants are shrubby species of perennial *Eriogonum*, including *E. fasciculatum*, *E. umbellatum*, and others. The specific name is a misnomer; it is not associated with *Lupinus*. *P. lupini* appears to be univoltine, but much remains to be learned about its food habits, due to long confusion with *P. acmon*.

P. lupini is broadly sympatric with *P. acmon* over much of both their ranges, a circumstance that has been the cause of much confusion. Both may occur at both low and high elevations and in many types of habitats. Some of the extreme variation seen in some series of specimens labelled as *P. acmon* is due to the presence of both species in the series. Some of the specimens that I have seen labelled as *cottlei* appear to belong with *lupini*. A genitalic examination of the type material of *cottlei* would be desirable, and would serve to fix the position of this name.

I have examined material from the Rocky Mountains, labelled as *lutzi* dos Passos, which appears to consist of both species mixed. Here again, genitalic examination of the type material of *lutzi* would be desirable to fix the position of this subspecies. Often *lupini* and *acmon* can be recognized by appearance, but in the last analysis the male genitalia offer the best means of separating these closely related but distinct species.

The population with green males, named *chlorina* by Skinner (TL Tehachapi, Kern Co., Calif.), shows some genitalic difference from nominate *lupini* in the shape of the superior process of the valve. This structural difference is also found in the Southern California population *monticola* Clemence (TL, by inference, San Gabriel Mountains, Los Angeles County, Calif.). *Monticola*, while distinctive in coloration, is in other respects very close to *chlorina*. *Chlorina* is found in the Tehachapi Mountains and south to the Mt. Pinos area, where it appears to intergrade to *monticola*. *Monticola* is found in pure form in the San Gabriel mountains and southward. It is possible that further study will show that the *chlorina-monticola* populations form a separate species. They are here regarded as well-marked subspecies of *lupini*.

A word about the Olympic Mountains population named *spangelatus* by Burdick (TL Gray Wolf Range, Olympic Mountains, Clallam County, Wash.). This was originally described as a subspecies of *lupini* (Burdick, 1942). On a reprint sent me by Burdick there is this penned notation: "Recent genitalic research indicates affiliation with *shasta* rather than *lupini*. / W. N. B." Material which I took in Olympic National Park and which I considered to be *spangelatus*, belongs genitally with *lupini*. This same material has been examined by Dr. Clench, who came to the same conclusion.

However, I have been informed by Mr. Carll Goodpasture that he has examined one of Burdick's paratypes and considers it to be genitally *acmon*. It appears that both *lupini* and *acmon* occur in the Olympic Mountains, and that Burdick may have had a mixed type series. The final decision on the affinities of *spangelatus* Burdick would appear to rest on a genitalic examination of the type, which is in the Canadian National Collection at Ottawa. In any event, the notation of Burdick to the contrary, it seems unlikely that the name *spangelatus* can be associated with *P. shasta*.

Plebejus (Icaricia) neurona (Skinner) 1902

Ent. News 13:15 (TL Doble, San Bernardino Co., Calif.)

This species, averaging the smallest in the subgenus, is unique in coloration, brown with orange veins in both sexes, entirely without blue.

Male Genitalia: Nearly or quite identical with *acmon*; there seem to be no constant differences.

Neurona is found in southern California, from Walker Pass in Kern County, southward in isolated colonies. The Mt. Pinos region of Los Angeles-Kern-Ventura Counties has a considerable concentration of the species. *Neurona* is apparently univoltine and is usually found in close proximity to its food plant, *Eriogonum Wrightii*. It is sympatric with *icarioides*, *lupini* (*chlorina*), and with *acmon*, at least in the Mt. Pinos region. The highly colonial distribution of *neurona* may be in part an artifact of incomplete collecting. On the other hand, I have seen rather extensive growth of *Eriogonum Wrightii* with no detectible *neurona* associated with it.

The unique coloration of *neurona*, a marked departure from that of the other members of the subgenus, and in fact, from that of the family, suggests that it has differentiated more recently than the other members of its group. The close structural relationship of *neurona* to *acmon* suggests also that *neurona* may have evolved from *acmon* in relatively recent times.

The illustrations are the work of Mr. Carll Goodpasture, to whom I am indebted for their use.

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THE CORRECT NAME FOR
THE SUBSPECIES OF
LIMENITIS WEIDEMEYERII
OCCURRING IN ARIZONA (NYMPHALIDAE)

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Mendham, N.J.

THERE APPEARS TO BE CONSIDERABLE CONFUSION in the literature concerning the correct name to be used for the population of *Limenitis weidemeyerii* Edwards (1861, p. 162) occurring in Arizona. The latest authors to publish on this subspecies, although not giving particular attention to the problem of the correct name, are Perkins and Garth ("1972" [1973], p. 229). They use the name *angustifascia* Barnes and McDunnough (1912, p. 163). Prior to Perkins and Garth, Brown (1967, pp. 371, 372), apparently to be on the safe side, had used *sinefascia* as a subspecies and even a specific name. In a couple of instances he even wrote the name with a hyphen ("*sine-fascia*").

It would be well to examine the synonymy of these names to see just what has been going on and to reach a correct conclusion as to the proper name to use in the light of the language of the International Code of Zoological Nomenclature (1964). Incidentally, the Code was further amended at Monte Carlo in 1972, and a new edition is promised for the end of 1973. So far as the author recollects, none of these amendments affect the questions discussed in this paper.

The synonymy of ab. *sinefascia* Edwards (1882) and *angustifascia* Barnes & McDunnough (1912) is as follows:

Limenitis weidemeyerii aber. *sine-fascia* Edwards, 1882, p. 22, type locality near Tucson, Arizona, corrected by Brown (1967, p. 371) to near Prescott, Arizona

Limenitis weidemeyerii aber. *sine-fascia* Edwards, 1884, p. 43, no. 238.

Limenitis weidemeyerii aber. *sine-fascia* Edwards, Smith, 1891, p. 2, no. 158

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- Limenitis weidemeyerii* aber. *sine-fascia* Edwards, Skinner, 1898, p. 29, no. 163
- Basilarchia weidemeyerii sinefascia* Edwards, Dyar, "1902" [1903], p. 26, no. 238
- Limenitis weidemeyerii sinefascia* Edwards, Smith et al., 1903, p. 4, no. 177a
- Limenitis sinefascia*; Wright, 1905, p. 180, no. 238
- Basilarchia weidemeyerii angustifascia* (Barnes & McDunnough), 1912, p. 163, type locality White Mountains, Arizona; type *ex coll.* Barnes, U. S. Nat. Mus.
- Basilarchia weidemeyerii* aber. *sinefascia* Edwards, (Barnes & McDunnough), 1912, p. 163
- Basilarchia weidemeyerii angustifascia* aber. *sinefascia* Edwards, (Barnes & McDunnough), 1917, p. 12, no. 306a
- Limenitis weidemeyerii* aber. *sinefascia* Edwards, Seitz, "1924" (1915), p. 534
- Limenitis weidemeyerii* form normal *angustifascia* Barnes & Benjamin, 1924, p. 99 (*lapsus calami*)
- Basilarchia weidemeyerii sinefascia*; (Barnes & Benjamin), 1924, p. 99
- Basilarchia sinefascia* (Edwards), (Barnes & Benjamin), 1926, p. 15, no. 309
- Basilarchia weidemeyerii sinefascia* form normal *angustifascia* (Barnes & McDunnough), Barnes & Benjamin, 1926, p. 15, no. 309b
- Basilarchia astyanax arizonensis* aber. *sinefascia* Edwards, Gunder, 1934, p. 44
- Basilarchia weidemeyerii sinefascia* Edwards, McDunnough, 1938, p. 22, no. 323b
- Basilarchia weidemeyerii sinefascia* form normal *angustifascia* Barnes & McDunnough, McDunnough, 1938, p. 22, no. 323a
- Limenitis weidemeyerii angustifascia* Barnes & McDunnough, Bauer, 1952, p. 130
- Limenitis weidemeyerii sine-fascia* Edwards, Bauer, 1954, p. 130
- Limenitis weidemeyerii sinefascia* Edwards (= *angustifascia* Barnes & McDunnough, 1912), dos Passos, 1964, p. 75, no. 519
- Limenitis weidemeyerii sinefascia*; Brown, 1967, p. 371
- Limenitis sine-fascia*; Brown, 1967, p. 371
- Limenitis sinefascia* Edwards, Brown, 1967, p. 372, fig. 17 (holotype)
- Limenitis weidemeyerii angustifascia*; Perkins & Garth, "1972" [1973], p. 229
- Limenitis weidemeyerii angustifascia* aber. *sinefascia* Edwards, Perkins & Garth, "1972" [1973], p. 229

From this synonymy it is clear that "*sine-fascia*" was proposed as an aberrational name and hence, as Brown (1967, p. 371) states correctly, it had no standing in nomenclature. However, he is in error in stating (*ibid.*) that Barnes & Benjamin (1926, p. 15) were the first authors to give it specific or subspecific standing and hence it must be ascribed to them. As we have seen, the first author to give *sinefascia* subspecific standing is Dyar ("1902", [1903], p. 26), so that name must be ascribed to Dyar. Since Dyar was assisted in writing his list of North

American Lepidoptera by C. H. Fernald, George D. Hulst, and August Bush, perhaps the name will have to be ascribed to Dyar *et al.* This action of Dyar does not appear to have been followed by subsequent authors, and Barnes & McDunnough (1912) even proposed *angustifascia* for the Arizona population of *L. weidemeyerii* but later (1924) recognized *sinefascia* as the correct name and gave their new name the style form normal "*angustifascia*" [sic]. Since that time most authors have considered *sinefascia* as the correct name, although Bauer (1951) slipped back into writing it with a hyphen. Then along came Brown (1967) who exhausted all three possibilities, i.e., specific, subspecific, and hyphenated, the latter contrary to the Code (Art. 26 a-c, 27, 34) as well as stating incorrectly that Barnes & Benjamin (1926) had given it subspecific standing when Dyar had done that 23 years earlier!

While the Code permits an aberrational name to be raised to specific or subspecific rank (Art. 10b), there is no provision for reducing an aberrational name to its prior status or for naming a normal individual. So for the present, *angustifascia* must be considered a synonym of *sinefascia* and the authorship of that name changed from Edwards, 1882, to Dyar *et al.*, "1902" [1903]. No objection is seen to treating *angustifascia* as the normal form until the Code is amended to cover this situation.

Since both *Limenitis astyanax arizonensis* Edwards, (1882) and *L. weidemeyerii sinefascia* Dyar ("1902" [1903]) occur in Arizona, it is possible that *sinefascia* is actually a hybrid similar to ab. *doudoroffi* (Gunder, 1934). This was suggested by Perkins and Garth ("1972" [1973], p. 232), and it is to be hoped that someone nearer to the scene than the present author may be able to pursue this problem.

The type of ab. *doudoroffi* is in The American Museum of Natural History.

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A REVIEW OF
CARRYING PAIR BEHAVIOR
AND MATING TIMES
IN BUTTERFLIES

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INTRODUCTION

ALTHOUGH THE KNOWLEDGE OF THE CARRYING HABIT of mating pairs in butterflies has periodically been augmented by data accumulation or a short note, there appears to be a kind of prejudice—unspoken—that says this subject is scientifically unimportant. For whatever reason (possibly the misconception that *in copulo* pairs always take flight only in stress situations and that either sex will fly under such circumstances), data in this field has been slow in coming. In 1920 Warren remarked "how fragmentary our knowledge of these flying-habits is, and how much further records are to be desired." As long ago as 1836, Donzel correctly realized that carrying pair records can be of broad taxonomic importance. In a recent review (1968), Miller & Clench drew attention once again to the inflexibility of the habit (i.e. either male carries female, or female carries male, or both) in the various butterfly families. In view of the scattered and fragmentary nature of such information and the need for an up-to-date treatment, we have attempted a synopsis. We are also aware that data on carrying pairs is rather difficult to accumulate and have included our records on the subject. We have made a modest attempt at summarizing the pertinent literature while realizing that the immensity of it prohibits a really comprehensive treatment.

Whether it is a male or female which is the carrying partner is significant in phyletic considerations if (1) there is a family or generic stability, (2) many records are consistent for one

sex, and (3) both adults of the *in copulo* pair are capable of flight (i.e. the passive partner is not newly emerged). For example, in hilltopping species such as *Erynnis tristis* where female carries male consistently, the partners could not have emerged at the mating site. Since the male invariably initiates the courtship (although we have seen a reference to one *Ornithoptera* exception), all female carrying male records must be for both adults with well-developed wings. Only male carrying female records need be suspect in phyletic considerations since this condition could either be due to a legitimate behavioral trait or merely due to the female having "wet" wings and not yet capable of flight. E.g., in *Danaus gilippus berenice* the male carried the female consistently in 78 pairs at the mating site, where both adults went through the courtship flight (Brower, Brower, & Cranston, 1965), while in pierids where the male nearly always carries the female, the female sometimes is newly emerged. However, if both partners take part in initial courtship as one of us (O.S.) has observed consistently in *Anthocaris cethura*, the carrying pair observation is phyletically valid when the male is the active partner.

CARRYING PAIR SUMMARY

Table 1 lists the carrying pair records we are aware of for butterflies. Warren (1938) and Miller & Clench (1968) have presented what they consider the general trends within butterfly families. We disagree with the latter authors in generalizing that the female is usually the active partner in Lycaenidae (see below). The data presented here indicate that the male carries the female in Pierinae (except *Aporia crataegi*), Coliadinae, and Danainae. The female carries the male in Papilioninae, Parnassiinae, Satyrinae (most reports), Riodininae (only one species reported), Theclini (5 species; also female walked male forward in *M. loki* [69], but either walked in *I. iroides* [68]), Hesperinae, and Pyrginae. Either male carries female or female carries male in Acraeinae, Nymphalinae (in favor of female carrying male), and Lycaeninae (in favor of male carrying female, excluding Theclini). It may be worth noting that the only species of hesperiid where male carried female (one pair out of eight, in *Erynnis tristis*) did so when the male was harassed by another *tristis* male that investigated the pair in his territorial area. Occasional alternation of the carrying sex develops when the pair is continually disturbed (see Table 1). Additional records are badly needed; there are a number of

subfamilies as yet unreported. Past impassioned appeals for more records (e.g. Bandermann, 1921) have been largely unheeded. Authors such as Warren (1920) and Miller & Clench (1968) point out that determining which sex is carrying is not always an easy matter and not to be hastily attempted.

BEHAVIOR

Copulation begins after the pair has alighted on a substrate (Ford, 1957:100). Miller & Clench (1968) note that *in copulo* pairs tend to remain motionless unless disturbed. Although the courtship is usually rather conspicuous in some groups, *in copulo* pairs remain camouflaged on bark of sticks (*E. tristis*, Shields, 1967), tree trunks (*N. antiopa*, Pronin, 1964), on top of trees (*A. iris*, Heslop, 1960), in tree foliage, in bushes on leaves (*H. crysalus*, Chambers, 1962; *I. iroides*, Powell, 1968), on the extremities of stems, and on rocks, often the sites of initial copulation. We have noted *in copulo* pairs of *C. tullia californica* and *D. plexippus* flying into trees when disturbed, also reported for *A. hyperantus*, *A. crataegi* (Sermin, 1954), and *A. paphia* (Weitbrecht, 1920). *In copulo* pairs on their larval foodplants, namely *C. viridis*, *C. dumetorum*, *L. argyrognomon anna*, and *Philotes* reported here, usually perched on the extremities of the bush. A disturbed pair of *P. sennae* repeatedly lit in the underbrush. However, two *P. shasta* pairs were fully exposed on the ground. Sermin (1954) noted one *in copulo* pair of *G. rhamni* hanging on a tree stump. Females of *E. editha* (Labine, 1966: 91) and *M. arion* (Sermin, 1954) sometimes carry the pair deep into the grasses. Occasionally mating pair females are found feeding on flowers (e.g. *Speyeria idalia*, Clark, 1932: 107; *Phyciodes mylitta*, present paper).

During the Dictionary Hill hilltopping study, O.S. noted that *P. zelicaon*, of those recorded, coupled at or adjacent to the summit in 10 pairs and flew downslope (more than 50') to mate in 5 pairs. The breakdown of mating sites in *zelicaon* was as follows:

no. pairs	Site	Height above ground
3	Artemisia	1-1½'
5	Rhus	2-3'
2	Eriogonum	2-3'
1	Baccharis	2'
1	Brassica	6''
1	on ground in brush	0
2	unspecified plants	2-3'

In *copulo* pairs of *E. tristis* in that study perched on *Rhus* 2-3' high in 5 pairs and on *Baccharis* 1-3' high in 15 pairs, with one pair on a rock, one pair on a dead weed, and one pair on a bush composite, all on the summit. In *A. cethura*, one pair was on wild oats 1' high, one pair on *Baccharis* 3' high, and one pair on vegetation 15" high, on the summit. All these pairs were rather inconspicuous, to the human observer, when perched on vegetation, and presumably would likewise be so to a vertebrate predator.

In the *in copulo* pairs we have observed that are hanging on vegetation, the male carries the female when the male is up and the female facing down and the female carries the male if the female faces up. Also, the carrying partner is the uppermost when the pair again alights (e.g., *M. jurtina*, *P. brassicae* in Dixey, 1915; *A. crataegi* in Sermin, 1954; and our observations). If copulation is initiated vertically on a substrate, the male or female walks around to face down after initial copulation depending on the species, so that the uppermost partner is the carrying partner. It may be that the *in copulo* pair is perched up at a vantage point where the carrying partner is alert to disturbances, to take flight when a predator approaches at this vulnerable time. We have noticed that *in copulo* pairs are frequently quite wary when approached, often repeatedly flying and alighting or flying a fair distance before alighting. One pair of *Aphantopus hyperanthus* flew off over a stagnant pond (Sermin, 1954). A "post-nuptial flight" by the *in copulo* pair away from the area of initial copulation, without provocation, has been observed in *Danaus* (Urquhart, 1960: 153; Brower, Brower, and Cranston, 1965: 16). Table 2 summarizes the distances travelled by some *in copulo* pairs.

Some reports indicate that the active partner continues to carry the passive partner even when it is in a worn, decrepit wing condition. Colthrup (1917), in reference to a *Fabriciana niobe* pair, says, "I have seen a male of this species, so worn and broken as to be incapable of flying more than a yard or two at a time, paired with a large, heavy, newly emerged female, making strenuous efforts to escape capture." He also says in *Melanargia galathea* the male carries female even when the male is "worn to rags." Of *Argynnis paphia*, Tutt (1901) says, "It is remarkable that, however worn and battered, and apparently incapable the male may be physically to accomplish such a flight, the female never attempts, in my experience, to fly."

Carpenter (1935) has pointed out that which sex carries is not merely a matter of size since in some, either sex may carry. Carpenter (1918a) noted that in Pierinae, the male always carries even when smaller than the female, e.g. in an *Eurema brigitta* pair. He also mentions that in some *Acraea*, the larger female was carrying the smaller male in two species, and in one species the larger male was carrying the smaller female. The smaller female carried the larger male in some pairs of *Aphantopus hyperantus* and *Maniola jurtina*; in both cases the female could only make a short flight with its burden (Sermin, 1954). The larger female carried a smaller male in an *Issoria lathonia* pair (Sermin, 1954), and a larger male carried a smaller female in *Syntarucus telicanus* (Carpenter, 1918a). One might suppose that there would be selection for females carrying males in species with heavy-bodied females, as in, e.g., *Papilio*, *Euphydryas*, and hesperiids, with a selection for male carrying female in species with lighter-bodied females, as in, e.g., Pieridae, *Danaus*, and many lycaenids. In one case, there would be more chance of escape from predation if the heavier individual flew, and in the other case where little or no weight difference exists, the more vulnerable active partner should be the male, for in the event of an attack, the female may escape for propagation purposes. In this regard, we should mention here that in *copulo* pairs separated upon capture in *Limenitis camilla* (Wheeler, 1917) and *Lasiommata megera* (Sermin, 1954), and we have noted separation of an *in copulo* pair with *Pieris protodice* (when missed with a net swing) and *Erynnis tristis* (when net clamped over pair). However, we have noted that many pairs did not separate upon capture or harassment.

Sermin (1954) performed a simple experiment. With an *Aphantopus hyperantus in copulo* pair, where female carries the male, he held the female by the wings; the male did not fly off and remained passive. Bryk (1921) noted that in *Pieris napi* the male carries the female, but when he killed the male in a tandem pair by pinching its thorax, the female flew with the dead male, repeatedly. Clark (1932: 159) noted with *Colias philodice*, where male carries female: "I once caught a white female that was carrying a yellow male. But on examination the male proved to be dead, probably having been killed by a phymatid bug or a crab spider." We have seen no mention of both members of a pair flying simultaneously; one of the pair is always passive in flight. When the flying partner alternates, the previous active partner becomes passive. This passive state

might be analogous to "death feigning" that butterflies such as *Nymphalis* and *Euphydryas* assume when directly threatened (i.e., wings appressed, legs folded against thorax).

We know of females with wet wings (unexpanded or recently expanded) or "newly emerged" females *in copulo* in *Colias eurytheme* (Stern & Smith, 1960: 419), *Pieris protodice* (Ferris, 1969), *Pieris napi* and *P. bryoniae* (Petersen, 1952), *Eurema nicippe* (present paper), *Brintesia circe* (Verity, 1919), and *Fabriciana niobe* (Tutt, 1901; Colthrup, 1917). Sometimes these were being carried in the carrying flight. Females of these pairs are almost assuredly incapable of flight. *In copula* pairs with one sex unable to fly are certainly the exception. Stern & Smith (1960) note that *Colias eurytheme* generally mates after the female's wings have thoroughly hardened.

DURATION OF COPULATION

Records for duration of copulation in butterflies are not common but indicate that the length of time is considerable. An undisturbed *Papilio zelicaon* pair on Dictionary Hill summit, XII-22-67, took 36 minutes from inception to break-up. An *Aporia crataegi* pair noted from inception was still *in copulo* after one hour, when the pair was induced to make carrying flights (Sermin, 1954). *Pieris rapae crucivora* remained 80 minutes *in copulo* (Obara, 1967). A *Danaus plexippus* pair was *in copulo* for 1½ hours but it was not stated if start and finish were noted (Urquhart, 1960: 52). *Danaus gilippus berenice* duration is reported to be ca. 1-2 hours by Brower, Brower, and Cranston (1965: 16) and 4½ hours or longer by Pliske and Eisner (1969). For 25 pairs of *Incisalia iroides*, Powell (1968) noted, "In one instance a pair separated before sunset, after not more than two hours, 40 minutes of mating, but in most other cases copulation lasted four to six hours and occasionally as long as seven or eight hours." In 13 laboratory crosses in *Poanes hobomok*, the duration ranged from 27½-56 minutes with a mean of 38¼ minutes (Burns, 1970). In one undisturbed pair of *Erynnis tristis*, hook-up to break-up lasted 61 minutes (Shields 1967: 141).

Pieris napi in the lab at 6.5°C remained 5 days *in copulo* and separated within ½ hour when placed in 20°C, but another pair lasted only a day at 7.2°C (Petersen & Tenow, 1954: 189). Burns (1970) noted that cloudiness and lower temperatures

prolong duration of copulation; "presumably it cannot be prolonged indefinitely because of the logistics of spermatophore production." Two females collected on Dictionary Hill, after being *in copulo* for 6½ minutes in *Anthocaris cethura* and 9 minutes for *Callophrys dumetorum*, had already received a new spermatophore (Shields, 1967). If this proves to be the rule in butterflies, that the spermatophore is passed early in the *in copulo* period, why do butterflies remain *in copulo* for such a long period? One might otherwise suppose that the prolonged copulation is necessary for the complete transfer of the spermatophore.

GENITALIA

References to the morphology of the genitalia in Lepidoptera would nearly fill a library but references to actual function are scarce (Lorkovic, 1953). Papers dealing with the morphology of the valvae in butterflies include White (1878), Gosse (1883), and Sibatani et al (1954). Forbes (1939) gives a discussion of valvae muscles in butterflies. Apparently many authors are impressed by the large "claspers" or valvae and their vice- or jaw-like grip of the female's abdomen during copulation as the method of holding the pair securely together during the "carrying" flight (e.g. Wallace, 1865:35; Gosse, 1883:271; Klots 1951:40; Ford, 1957:100; Urquhart, 1962:52). However, Lorkovic (1953) has demonstrated by excision experiments in many European butterflies that instead it is the uncus (plus gnathos where present) which curves into a hook into a pocket under the ovipore, that is mainly responsible for the secure grip, the valves having a negligible effect.

When coupling, the male clasps the end of the female's abdomen with his valvae, uncus, gnathos, and falces before inserting the aedeagus into the bursa copulatrix (Klots, 195-). The manner of the initial attachment of the male abdomen to the female's in some species is described by Richards (1927:339) and Brower, Brower and Cranston (1965). In *Colias eurytheme* this grasp is on "the chitinous plate surrounding the ovipositor and ostium bursae" (Stern & Smith, 1960:420). The uncus first attaches, then the valves compress the end of the the female's abdomen laterally (Lorkovic, 1953; Hannemann, 1954; Stekol'nikov, 1965). The aedeagus insertion into the bursa copulatrix of the female further aids in anchorage (Hannemann, 1954). Rather detailed accounts of genitalia extrusion during copulation are given for Plebeidi (Chapman, 1916) and *Argynnis paphia*

(Hannemann, 1954). Hardwick (1965) describes the mechanics of copulation in the noctuid moth *Helicoverpa*, and Stekol'nikov (1965) discusses muscle actions associated with the copulation sequence in moths.

In *Argynnis paphia* the male genitalia is extruded by means of contraction of the pleural muscle fibers which unite the lateral sections with either the tergite or the sternite in the abdomen; retraction of these muscles restores the genitalia to its normal internal condition (Hannemann, 1954).

Lorkovic (1953) notes that although the uncus is rather uniform in most genera, there is a diversity of valve forms. The aedeagus and ductus may change form between two closely related species in Plebeidi (Chapman, 1916). Lorkovic says the marked variation in butterfly genitalia results from the genitalia's complete uselessness to that individual's existence, allowing it to vary far greater evolutionarily than, e.g., feet. He reasons that since rather large differences in genitalia do not prevent interspecific hybridizations in the lab (where they were mechanically paired), in nature these pairings are prevented by sexual odor differences. (We believe that courtship behavior differences also probably aid in preventing interspecific pairings.)

Carrying pairs, or phoretic copulation, is also known in three Hymenoptera families (Bethyridae, Tiphidae, and Mutillidae), with winged males and wingless females (Evans, 1969). Here, major specializations in both male and female genitalia produce an extremely firm interlocking of their genitalia in flight. Certain Mutillidae even have modifications of the male's mandible, apparently to capture the female prior to copulation (Sheldon, 1970). Reasons surmised for this prolonged copulation with flight in certain Hymenoptera include: (1) adaptation to rival male interference, (2) an escape mechanism from predators, or (3) both (Lin, 1966; Evans, 1969).

A peculiar *in copula* posture is assumed by some species of *Incisalia* and *Erynnis*. Cook (1907) describes this pose for *I. henrici*: 'The posture of the butterflies during *coitus* merits attention, as it doubtless explains or is explained by the peculiar modification of the genitalia found in the Theclini. . . . these butterflies held their abdomens high so that they formed an angle of about ninety degrees. . . . The wings were closely appressed, the secondaries lifted away from the body, and the primaries dropped forward between them so that, except for the projecting apices, they were completely hidden. Whenever

the female moved forward even a little the male would immediately back up until the position described was regained, acting as though any other position was painful, or at least uncomfortable." The same posture pertains to *I. iroides* in cop. (Powell, 1968).

During the Dictionary Hill study, O. S. observed some *Erynnis tristis* in copulo pairs resting in a position about 30 degrees from the horizontal (Shields, 1967, fig. 14). Burns (1964) says that the asymmetry in *Erynnis* genitalia is exceptional in skippers; "an aedeagus directed toward a male's right requires an ostium bursae situated on the female's left" (p 5).

In other species that we have noticed, the pose is linear.

INTERSPECIFIC HYBRIDS AND COURTSHIPS

Known wild-caught hybrids have been reported within the genera *Papilio*, *Parnassius* (Heydemann, 1943), *Anthocaris*, *Colias*, *Limenitis*, *Lycaena*, *Agathymus*, *Carterocephalus* (Alberti, 1943), etc. Hybridization within a genus might be expected but there is no evidence as yet that higher crosses (e.g. inter-generic, inter-family, butterfly X moth) are ever successful. Downey (1962) maintains that cross-matings are rarely attempted; "some of the reasons for this may be involved in size, behavioral characteristics, time of flight, time of maximum activity, seasonal cycles, and micro-ecological niches." Peterson (1952) and Peterson & Tenow (1954) have had no trouble producing crosses between *Pieris napi* and *P. bryoniae* for several generations but note that in nature the isolating factors of elevation, emergence time, and food plant differences prevent them from crossing. Wright (1906) gives a rough estimate that about one in 70 (not one in 140 as originally reported: see Downey, 1962) are mismatings, in his experience. Table 3 lists the copulation instances of mismatings that we are aware of. In the few instances of two males taken "in copulo", perhaps the proper behavioral cues were elicited for courtship and subsequent mating; the two instances that are reported were between two different species. (In addition, some 12 unusual pairings between moths are given by Graves, 1894; Perkins, 1914; de Fleury, 1934; and Downey, 1962.)

Courtships between two different species are occasionally encountered and could result in a "mismating." Toliver (1968) reported a male *Megathymus yuccae coloradensis* Riley court-

ing a female *M. streckeri* (Skinner); the male attempted to copulate but the female flew up, at which point both were netted. He notes that it was an unusual year in that the two were sympatric, usually being temporally isolated by two or three weeks. O'Byrne (1948) noted a much-worn male *Phyciodes nycteis* (Dbl. & Hew.) courting over a *P. gorgone* (Hbn.) female for more than half an hour. The female "responded as to a male of her own species." The event was ended by a thunderstorm.

During the Dictionary Hill hilltopping work, O.S. observed two inter-generic courtships. On March 19, 1967, a worn male *Papilio zelicaon* courted a MALE *Euphydryas chalcedona* between 11:38-11:39 a.m. PST, 66°F, 70% R.H. The *zelicaon* many times performed a bobbing flight behind and in front of the *chalcedona*, as male *zelicaon* do while courting females. When the *chalcedona* alighted, the *zelicaon* landed on top of him with his legs, causing the pair to fly up (repeated three times). The *zelicaon* followed the *chalcedona* in flight closely the whole time. The other courtship was between a male *Vanessa atalanta* and a fresh female *Papilio zelicaon* on January 8, 1967, 12:47 p.m. PST, 60°F, 35% R.H. The *zelicaon* was first noticed in low circling flights over the summit, as performed by virgin female *zelicaon*. When the *atalanta* investigated the female, the *zelicaon* broke into a fluttering, hovering flight and descended slowly toward the ground. The pair eluded capture, and the female flew rapidly downhill.

We know of two moth-butterfly courtships. Heitzman (1964) found a male *Thorybes pylades* Scudder courting a male *Euclidina cuspidea* Hubner, a noctuid moth. The *pylades* dipped lower and lower until the moth took flight, eleven times, before the moth crawled deeply into the grass. Two other "courtships" between these two species occurred that day, and both times the *pylades* quit while the *cuspidea* was still resting in the open. *Polites sabuleti* near *comstocki* Gunder were extremely abundant in an alkali grass field on August 30, 1964, at Waford Spring, 6500', on Hwy. 31, 10½ air mi. NE of Lee Vining, Mono Co., Calif., leg. O.S. The numerous males often "boiled" around each other and pursued two species of unidentified whitish moths that superficially resembled the pale female *comstocki* in color. In the instances above and in Table 3, it may be noteworthy that the moths attended by male butterflies have been approximately the same color as that butterfly species' female, although their size may be larger or smaller than the female butterfly, with somewhat different flight habits.

MATING TIME

From Table 4, a few tentative generalizations can be made about when species mate, for the most part in agreement with the views of Miller & Clench (1968). The evidence is against the belief that butterflies mate at any time during the day. Those groups that mate mostly from mid-morning to early afternoon include *Papilio zelicaon* (primarily between 11:00-12:30 PST), *Argynnis*, *Speyeria*, *Phyciodes*, *Euphydryas*, *Chlosyne*, *Callophrys*, and *Celastrina*. Those that mate from mid-morning to mid-afternoon are *Philotes*, *Plebejus*, and *Erynnis tristis* (primarily between 11:30-1:00 PST). Those from mid-morning to late afternoon include Satyrinae, Coliadinae, and *Pieris*. *Danaus* pairs are mostly found in the late afternoon and possibly remain *in copulo* overnight in some cases. Late afternoon to early evening mating occurs in *Vanessa*, *Hypaurotis*, *Satyrrium*, and *Incisalia iroides*. *Libytheana bachmannii* has been taken *in copulo* at U-V light in the evening. Many more observations are needed before definitive conclusions can be drawn.

Figs. 1 and 2 give the hourly spread of captured hilltopping females on Dictionary Hill summit for *Papilio zelicaon* and *Erynnis tristis*, although there is a collecting bias. That is, most collecting tends to be done in mid-day since the weather is best at that time. The total number of times a given ½ hour interval was checked on the days that that species' females were collected are as follows (somewhat approximate):

	10-10:30	10:30-11	11-11:30	11:30-12	12-12:30
<i>P. zelicaon</i>	9	15	18	21	33
<i>E. tristis</i>	—	11	13	14	11
	12:30-1	1-1:30	1:30-2	2-2:30	2:30-3
<i>P. zelicaon</i>	29	23	13	10	6
<i>E. tristis</i>	10	6	5	2	—

In addition, 16 virgin female *P. zelicaon* from the release experiment arrived at the summit between 11:20-12:45 PST during a 3-day period.

Stern and Smith (1960) make the following observations about the mating time in *Colias eurytheme*: "In the San Joaquin Valley on very hot days, mating as well as general activity is more pronounced during the morning and late afternoon, while during midday, activity nearly ceases. On mild days, mating and other activity occur throughout the day. On cold days, there is very little activity."

Our records are given in Tables 5-8. Accompanying weather data is given for *P. zelicaon*, *A. cethura*, and *E. tristis*; Powell (1968) records weather information for 30 mating pairs of *Incisalia iroides*.

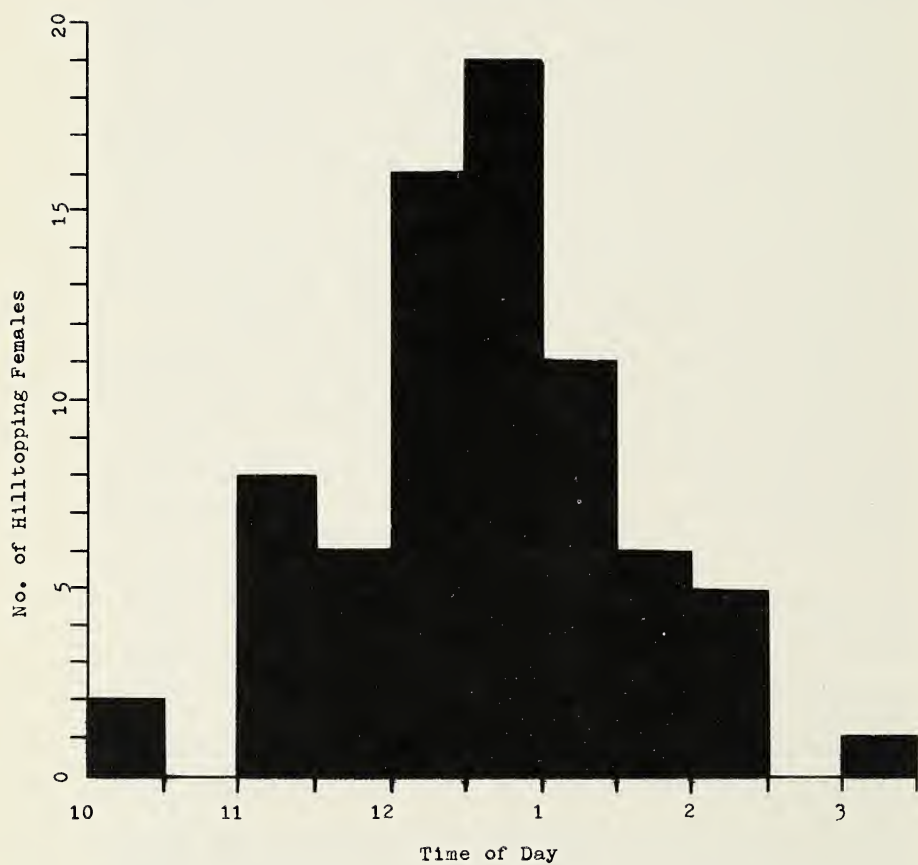


Fig. 1.—Numbers of *Papilio zelicaon* females that were present on the summit of Dictionary Hill during the day (see also Table 6).

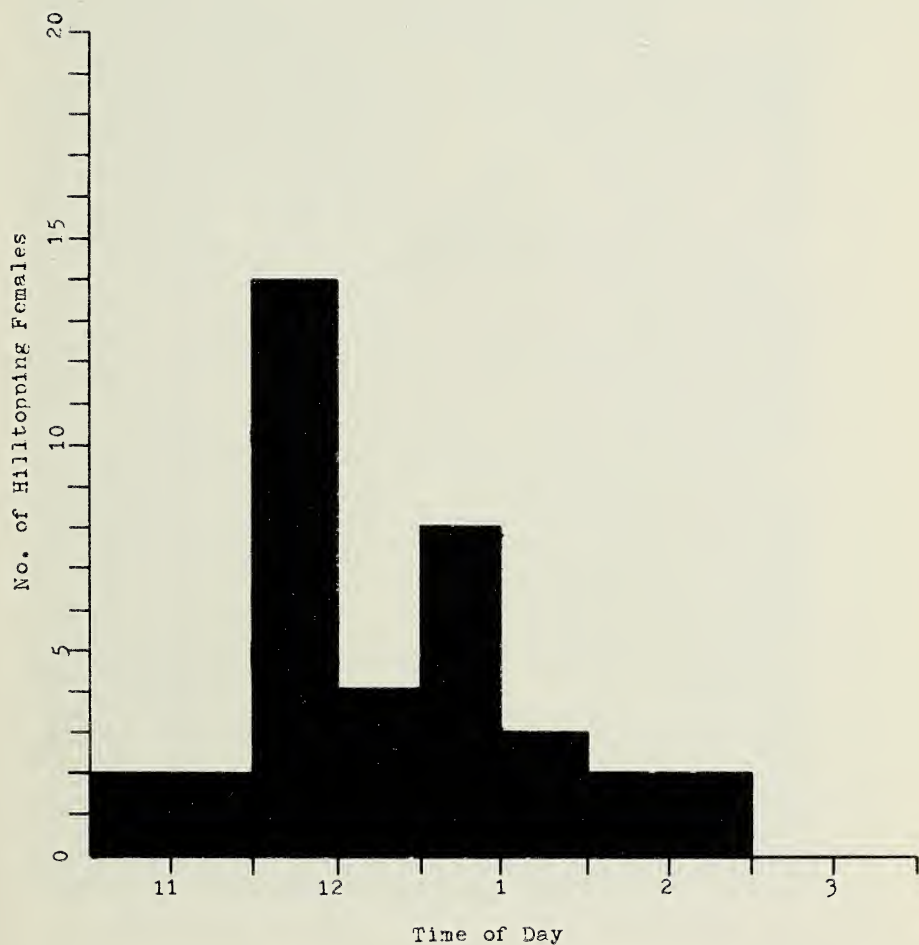


Fig. 2.—Numbers of *Erynnis tristis* females that were present on the summit of Dictionary Hill during the day (see also Table 8).

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Fig. 3.—*In copulo* pair of *P. zelicaon* perched in a *Rhus* bush on Dictionary Hill summit, female up, male down.



Fig. 4.—*In copulo* pair of *Speyeria nokomis apaeheana*, 1 mi. W. of Gull Lake, Mono Co., Calif., VIII-27-70, 1:10 p.m. (PST), male up, female down.

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Fig. 5.—In copula pair of *Satyrium sylvinus*, Stonyford, Colusa Co., Calif., VI-5-69, 3:45 p.m. (PST), female left, male right.

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TABLE 1 List of "carrying pair" records for butterflies

Species	male female		Alter- nating	References	Realm
	female	male			
PAPILIONIDAE					
Papilioninae					
<u>Papilio dardanus</u> Brown		1+		6	Eth.
<u>Papilio dardanus cenea</u> Stoll.		1		7	Eth.
<u>Papilio echerioides</u> Trimen		1+		6	Eth.
<u>Papilio jacksoni</u> Sharpe		1+		6	Eth.
<u>Papilio machaon</u> L.		1+		71	Pal.
<u>Papilio polytes</u> L.		1+		6	Ori.
<u>Papilio polyxenes</u> Fab.		2		28, 69	Nea.
<u>Papilio rudkini</u> Comstock		2		69	Nea.
<u>Papilio zelicaon</u> Lucas		2		69, 83	Nea.
Parnassiinae					
<u>Parnassius apollo</u> L.		1		98	Pal.
<u>Zerynthia polyxena</u> Schiff.		1+		24	Pal.
<u>Zerynthia rumina</u> L.		1+		24	Pal.
PIERIDAE					
Pierinae					
<u>Anthocaris cethura</u> F. and F.	1			83	Nea.
<u>Aporia crataegi</u> L.		14+		24, 71, 77, 97	Pal.
<u>Appias drusilla</u> (Cr.)	1			56	Neo.
<u>Belenois creonia severina</u> (Stoll)	10+			8, 21	Eth.
<u>Belenois gidica</u> Godt.	1			8	Eth.
<u>Catasticta nimbicincta</u> (Bdv.)	1			56	Nea.
* <u>Colotis achine</u> Cham.	3			8	Eth.
* <u>Colotis ducissa</u> Dogu.	1			8	Eth.
<u>Colotis euippe omphale</u> Godt.	1			7	Eth.
<u>Colotis evagore</u> Klug	1			8	Eth.
<u>Colotis evenina casta</u> Gerst.	17			8	Eth.
<u>Dixeia charina simana</u> Hopff.	34	1		8	Eth.
<u>Dixeia pigea</u> Bdv.	1			21	Eth.
<u>Eronia cleodora</u> Hubn.	1			7	Eth.
<u>Glycestha aurota</u> F.	10			8	Eth.
<u>Pieris beckerii</u> Edw.	1			69	Nea.
<u>Pieris brassicae</u> L.	10+			14, 21, 24, 34, 35, 75, 98	Pal.
<u>Pieris mannii</u> Mayer	1			97	Pal.
<u>Pieris napi</u> L.	24+			4, 14, 21, 26, 35, 44, 69, 71, 77, 97, 98, 104	Nea. Pal.
<u>Pieris protodice</u> Bdv. and LeC.	4			69, 83	Nea.
<u>Pieris rapae</u> L.	31+			13, 14, 15, 21, 24, 35, 44, 56, 71, 77, 104, 108	Nea. Pal.
<u>Pieris sisymbrii</u> Bdv.	4			69	Nea.
<u>Pieris virginienensis</u> Edw.	2			56	Nea.
<u>Pinacopteryx eriphia</u> Godt.	1			8	Eth.
<u>Pontia daplidice</u> L.	1+			24	Pal.
Coliadinae					
<u>Catopsilia florella</u> F.	2			8	Eth.
<u>Colias crocea</u> Fourcr.	3+	1+		18, 24, 56, 98	Pal.
<u>Colias eurytheme</u> Bdv.	2			56, 69	Nea.
<u>Colias hyale</u> L.	4+	1+		18, 24, 71, 77	Pal.
<u>Colias occidentalis chrysomelas</u> Edw.	1			69	Nea.
<u>Colias palaeno</u> L.	1+			91	Pal.
<u>Colias phicomone</u> Esp.	1			98	Pal.
<u>Colias philodice</u> (Godart)	1+			108	Nea.

TABLE 1 (cont.)

Species	male		female	carried	Alter-	References	Realm
	carried	female					
<u>Eurema brigitta</u> Cr.	1					7	Eth.
<u>Eurema desjardinsii regularis</u>							
Btlr.	1					8	Eth.
<u>Eurema hecabe senegalensis</u> Bdv.	1					8	Eth.
<u>Eurema lisa</u> Bdv. and LeC.	4					56	Nea., Neo.
<u>Eurema nicippe</u> (Cr.)	1					69	Nea.
<u>Nathalis iole</u> Bdv.	1					69	Nea.
<u>Phoebis sennae</u> (L.)	1					69	Nea.
<u>Zerene cesonia</u> (Stoll)	2					69	Nea.

SATYRIDAE

Satyrinae

<u>Aphantopus hyperanthus</u> L.		6+			71, 77, 101, 104,		Pal.
<u>Brintesia circe</u> F.	1+				95		Pal.
<u>Cercyonis pegala</u> (F.)		1			56		Nea.
<u>Cercyonis pegala boopis</u> (Behr)		1			69		Nea.
<u>Chazara briseis</u> L.	1				35		Pal.
<u>Coenonympha arcania</u>							
darwiniana Stgr.		1			98		Pal.
<u>Coenonympha gartetta</u> de							
Prunner		2			97, 98		Pal.
<u>Coenonympha pamphilus</u> L.		5+			13, 24, 35, 44, 101		Pal.
<u>Coenonympha tullia californica</u>							
(Westwood)		3			69		Nea.
<u>Coenonympha tullia tiphon</u> Rott.		1			97		Pal.

SATYRIDAE

Satyrinae (cont.)

<u>Erebia aethiops</u> Esp.		1			97		Pal.
<u>Erebia albertanus ceto</u> Hbn.		2			98		Pal.
<u>Erebia claudina</u> Borkhausen		2			98		Pal.
<u>Erebia euryale</u> Esp.		1			97		Pal.
* <u>Erebia goante</u> Esp.		1+			91		Pal.
<u>Erebia gorge</u> Esp.		4			97, 98		Pal.
<u>Erebia manto</u> Esp.		2			97		Pal.
<u>Erebia medusa</u> Schiff.		3+			71, 77		Pal.
<u>Erebia oeme</u> Hbn.		2			97		Pal.
<u>Erebia stirius</u> Godart, ssp.							
stelviana		1			98		Pal.
<u>Euptychia cymela</u> (Cr.)		2			56		Nea.
<u>Euptychia hermes</u> (F.)		1			56		Neo.
<u>Hipparchia neomiris</u> God.		1			98		Pal.
<u>Hipparchia semele</u> L.		3			14, 15, 21		Pal.
<u>Lasiommata maera</u> L.		4+			91, 97, 98		Pal.
<u>Maniola jurtina</u> L.	1+	36+			13, 14, 15, 18, 21, 24, 34, 35, 43, 44, 56, 71, 97, 101, 102, 104		Pal.
<u>Melanargia galathea</u> L.	4+	10+			34, 35, 71, 77, 92, 97, 101, 104		Pal.
<u>Minois dryas</u> Scopoli		9			77, 97		Pal.
<u>Pararge aegeria</u> L.		4+			71, 89, 101		Pal.
<u>Pararge hiera</u> L.		1			97		Pal.
<u>Pierella helvina incanescens</u>							
God. and Salvin		1			56		Neo.
<u>Pierella luna</u> (F.)		1			56		Neo.
<u>Pyronia cecilia</u> Vallantin		1			98		Pal.
<u>Pyronia tithonus</u> L.		9+			13, 15, 97, 98, 104		Pal.
<u>Satyrus actaea</u> Esper		1+			24		Pal.
<u>Ypthima asterope</u> Klug		1			7		Eth.

TABLE 1 (cont.)	male carried female	female carried male	Alter- nating	References	Realm
NYMPHALIDAE					
Danainae					
<u>Danaus chrysippus</u> L.	19			9	Eth.
<u>Danaus gilippus berenice</u> (Cr.)	78			3, 65	Nea.
<u>Danaus gilippus strigosus</u> (Bates)	5			56, 69	Nea.
					Neo.
<u>Danaus plexippus</u> (L.)	14+	1+		56, 69, 71, 93	Nea.
Acraeinae					
<u>Acraea caldarena</u> Hew.	26	1		7, 9	Eth.
<u>Acraea chilo</u> Godman		1		104	Eth.
<u>Acraea encedon</u> L.		6		7, 9, 78, 79	Eth.
<u>Acraea natalica</u> Bdv.		2		7	Eth.
<u>Acraea oncaea</u> Hopff.	1			7	Eth.
Nymphalinae					
<u>Adelpha bredowii</u> Geyer		1+		71	Nea.
<u>Anartia fatima</u> (F.)	1			56	Neo.
<u>Anartia jatrophae luteipicta</u>					
Fruhst.		1		56	Neo.
<u>Apatura iris</u> L.		1+		45	Pal.
<u>Argynnis paphia</u> L.	43+	14+		14, 22, 23, 34, 35, 44, 57, 71, 77, 92, 97, 100, 101, 103, 104	Pal.
					Neo.
<u>Asterocampa leila</u> (Edw.)		1		56	Neo.
<u>Boloria pales arsilache</u> Esp.		1+		35	Pal.
<u>Boloria pales palustris</u> Fruhst.		1		98	Pal.
<u>Brenthis daphne</u> Schiff.		1+		24	Pal.
* <u>Byblia goetzius</u> Herbst.	1			7	Eth.
<u>Chlosyne californica</u> (Wright)		1		69	Nea.
<u>Chlosyne damoetas malcolmi</u>					
(Comstock)		1		69	Nea.
<u>Chlosyne gabbii</u> (Behr)		3		69	Nea.
<u>Chlosyne leanira fulvia</u> (Edw.)		1		69	Nea.
<u>Clossiana euphrosyne</u> L.		1		60	Pal.
<u>Clossiana selene</u> Schiff.	1+			34	Pal.
<u>Clossiana titania cypris</u> Meigen		1		98	Pal.
<u>Euphydryas aurinia</u> Rott.		1+		44	Pal.
<u>Euphydryas aurinia glaciegenita</u>					
Vrty.		2		98	Pal.
<u>Euphydryas chalcedona</u> (Doubleday)		6		69	Nea.
<u>Euptoietia claudia</u> (Cr.)	2	2		56, 69	Nea.
<u>Fabriciana adippe</u> Schiff.	3+	2+	1+	21, 22, 101, 102,	Pal.
<u>Fabriciana niobe</u> L.	2+	1		34, 92	Pal.
<u>Hamanumida daedalus</u> F.		2		7	Eth.
<u>Hypolimnas misippus</u> L.		1+		6, 78	Eth.
<u>Issoria lathonia</u> L.	4+	1+		34, 35, 77, 92	Pal.
<u>Junonia coenia</u> (Hbn.)		1		69	Nea.
<u>Melitaea cinxia</u> L.		1+		44	Pal.
<u>Melitaea diamina</u> Lang.	1			98	Pal.
<u>Melitaea didyma</u> O.		6+		24, 35, 44, 92, 97	Pal.
* <u>Melitaea helvetica</u> Ruhl		2		98	Pal.
<u>Mellicta asteria</u> Freyer		1		98	Pal.
<u>Mellicta athalia</u> Rott.	1+	2+		24, 34, 97	Pal.
<u>Mellicta varia</u> M. -Dur.		2		98	Pal.
<u>Mesoacidalia aglaja</u> L.	5+	5+		24, 34, 35, 91, 92, 97, 101, 102	Pal.
					Pal.
<u>Microtia dymas</u> Edw.		2		69	Nea.
<u>Neptis "agatha"</u> Cr.		1		7	Eth.
<u>Pandoriana pandora</u> Schiff.		1		98	Pal.
<u>Phyciodes campestris</u> (Behr)		3		69	Nea.
<u>Phyciodes mylitta</u> (Edw.)		2		69	Nea.
<u>Phyciodes tharos</u> (Drury)		1		56	Nea.
<u>Precis actia</u> Dist.		1		7	Eth.
<u>Precis clelia</u> Cr.		1+		78	Eth.

TABLE 1 (cont.)

Species	male carried female	female carried male	Alter- nating	References	Realm
<i>Pseudacraea poggei</i> Dew.		1	7		Eth.
<i>Speyeria aphrodite</i> (F.)		1	56		Nea.
<i>Speyeria callippe</i> (Bdv.)		2	69		Nea.
<i>Speyeria callippe comstocki</i> (Gunder)		1	69		Nea.
<i>Speyeria cybele</i> (F.)		1	56		Nea.
<i>Speyeria cybele leto</i> (Behr)	1		69		Nea.
<i>Speyeria egleis</i> (Behr), ssp.		1	69		Nea.
<i>Speyeria hydaspe</i> (Bdv.), ssp.		1	69		Nea.
<i>Speyeria idalia</i> Drury		1+	108		Nea.
<i>Speyeria mormonia arge</i> (Strecker)	1	1	69		Nea.
<i>Speyeria nokomis</i> (Edw.)	1+	1+	56		Nea.
<i>Speyeria nokomis apacheana</i> (Skinner)	4		69		Nea.
LYCAENIDAE					
Riodininae					
<i>Apodemia mormo virgulti</i> (Behr)		2	69		Nea.
Lycaeninae					
<i>Agrodiaetus damon</i> Schiff.	3		97, 98		Pal.
* <i>Alaena interposita</i> Butl.		1	7		Eth.
<i>Albulina orbitulus</i> Prun.	5		97, 98		Pal.
* <i>Argus escherii</i> Hbn.	1+		24		Pal.
<i>Aricia agestis</i> Schiff.	1		15		Pal.
<i>Axiocerses amanga</i> Westw.		1	7		Eth.
<i>Chrysophanus titus</i> (F.)		1	56		Nea.
<i>Cupido minimus</i> Fuessly		2	98		Pal.
<i>Cupido osiris</i> Meigen	1		97		Pal.
<i>Cyaniris semiargus</i> Rott.		1	97		Pal.
<i>Eumedonia eumedon</i> Esper		1	98		Pal.
<i>Everes alcetas</i> Hoffmannsegg	1		97		Pal.
<i>Everes comyntas texanus</i> Chermock		3	56		Neo.
<i>Glaucopsyche alexis</i> Poda	1		97		Pal.
<i>Leptotes marina</i> (Reakirt)		1	69		Nea.
<i>Lycaena arota</i> (Bdv.)	1		69		Nea.
<i>Lycaena editha</i> (Mead)	1		69		Nea.
<i>Lycaena phlaeas</i> L.		1	97		Pal.
* <i>Lycaena subspina</i> Spr.	1		97		Pal.
<i>Lysandra bellargus</i> Rott.	3+		24, 97, 101		Pal.
<i>Lysandra coridon</i> Poda	22+		13, 15, 24, 35, 86, 89, 97, 98, 101, 104		Pal.
<i>Maculinea arion</i> L.		2+	71, 97		Pal.
<i>Meleageria daphnis</i> Schiff	1+		24		Pal.
<i>Nordmannia acaciae</i> F.		1+	24		Pal.
<i>Nordmannia ilicis</i> Esper		1+	24		Pal.
<i>Palaeochrysophanus hippothoe</i> eurydame Hoffmannsegg		1	97		Pal.
<i>Philotes battoides</i> (Behr), ssp.	5	1	69		Nea.
<i>Philotes battoides oregonensis</i> Barnes and McDunnough		2	69		Nea.
<i>Philotes enoptes ancilla</i> Barnes and McDunnough	1		69		Nea.
<i>Philotes enoptes dammersi</i> Comstock and Henne	2		69		Nea.
<i>Philotes enoptes smithi</i> Mattoni	1		69		Nea.
<i>Philotes rita</i> (Barnes and McDunnough)	1		69		Nea.
<i>Philotes rita pallescens</i> Tilden and Downey	1		69		Nea.
<i>Plebejus acmon</i> (Westw. and Hew.)	6	1	1	69	Nea.

TABLE 1 (cont.)

Species	male carried female	female carried male	Alter- nating	References	Realm
<u>Plebejus argus</u> L.	8+			14, 34, 71, 77, 98, 101, 104	Pal.
<u>Plebejus argyrognomon</u> Bgstr.	1+			101	Pal.
<u>Plebejus argyrognomon ricei</u> (Cross)	1			69	Nea.
<u>Plebejus saepiolus</u> (Bdv.)			1	69	Nea.
<u>Plebejus shasta</u> (Edw.)	1	1		69	Nea.
<u>Plebicula dorylas</u> Schiff.	5			97, 98	Pal.
<u>Polyommatus eros</u> O.	1			98	Pal.
<u>Polyommatus icarus</u> Rott.	29+			13, 14, 15, 21, 26, 34, 35, 44, 71, 77, 86, 89, 97, 101, 104	Pal.
<u>Strymonidia spini</u> schiff.		1+		24	Pal.
<u>Synfarucus telicanus</u> Lang.	1	4		7	Eth.
HESPERIIDAE					
Hesperinae					
<u>Atrytone conspicua</u> Edw.		1+		108	Nea.
<u>Hesperia harpalus leussleri</u> Lindsey		1		69	Nea.
<u>Hesperia juba</u> Scudder		3		54, 69	Nea.
<u>Hylephila phyleus</u> (Drury)		1		56	Nea.
<u>Ochlodes sylvanoides</u> (Bdv.)		1		69	Nea.
<u>Ochlodes venatus</u> Turati		1+		44	Pal.
<u>Polites peckius</u> (Kirby)		2		56	Nea.
<u>Polites sonora</u> (Scudder)		1		69	Nea.
<u>Thymelicus sylvestris</u> Poda		3		56, 77	Pal.
Pyrginae					
<u>Cogia calchas</u> (Herrich-Schaffer)		1		56	Neo.
<u>Erynnis brizo lacustra</u> (Wright)		1		69	Nea.
<u>Erynnis funeralis</u> (Scudder and Burgess)		1		69	Nea.
<u>Erynnis juvenalis</u> (F.)		2		56	Nea.
<u>Erynnis tages</u> L.		3		97	Pal.
<u>Erynnis tristis</u> (Bdv.)		7		69, 83	Nea.
<u>Pholisora catullus</u> (F.)		1		69	Nea.
<u>Polythrix asine</u> (Hew.)		1		56	Neo.
<u>Pyrgus alveus</u> Hbn.		1		98	Pal.
<u>Pyrgus alveus ryffellensis</u> Oberth.		1		97	Pal.
<u>Pyrgus carlinae</u> Rambr.		1		98	Pal.
<u>Pyrgus communis</u> (Grote)		2		69	Nea.
<u>Pyrgus malvae</u> L.		1		97	Pal.
<u>Pyrgus serratulae</u> Rambr.		1		98	Pal.
<u>Thorybes diversus</u> Bell		1		69	Nea.

Comments: A "+" by the number of pairs refers to an unspecified additional number or the possibility thereof based on the wording. We attempted to update the genera and species names to current usage but found no recent treatment of the few names with an asterisk. In Papilio polyxenes, ref. no. 28, it is almost certainly this species, and not P. bairdii as originally reported, in our opinion. Nea. = Nearctic, Neo. = Neotropical, Pal. = Palearctic, Eth. = Ethiopian, Ori. = Oriental.

TABLE 2 Distance travelled by in copulo pairs in flight

<u>Species</u>	<u>Distance</u>	<u>Source</u>
<u>Aporia crataegi</u> L.	over 30m (2X, same pair), 70 - 80m	77
<u>Pieris napi</u> L.	over 20m, 50m	77
<u>Pieris protodice</u> Bdv. and Lec.	ca. 20 yards	new
<u>Pieris rapae</u> L.	10-20m, 15-20m, 40-50m, ca. 50m, over 50m, over 60m, over 200 strides	77
<u>Colias hyale</u> L.	40m, 50-60m	77
<u>Aphantopus hyperanthus</u> L.	3-4m	77
<u>Lasiommata megera</u> L.	4-5m 8m, ca. 10m (2X, same pair), 20-30m	75, 77
<u>Maniola jurtina</u> L.	ca. 3-4m, 6-8m	77
<u>Melanargia galathea</u> L.	5-10m, over 20m	77
<u>Minois dryas</u> Schopoli	10m, ca. 40m, ca. 50m (2 pairs)	77
<u>Danaus gilippus berenice</u> (Cr.)	well over 1000' (max. 80' high; variable in height and distance)	3
<u>Argynnis paphia</u> L.	"the pair flew a great distance", ca. 20m	34, 77
<u>Issoria lathonia</u> L.	5-6m	77
<u>Polyommatus icarus</u> Rott.	2-3m	77
<u>Erynnis tristis</u> (Bdv.)	10', ca 10 yards (2X, same pair), ca. 50' (2 pairs)	new

TABLE 3 Interspecific pairings in butterflies

<u>COMBINATION (male X female)</u>	<u>Sources</u>
different species:	
1. <u>Pieris rapae</u> L. X <u>Pieris protodice</u> (Bdv. and LeC.)	107
2. <u>Colias eurytheme</u> Bdv. X <u>Colias philodice</u> Godart	47
3. <u>Colias hyale</u> L. X <u>Colias crocea</u> Geoffroy ab, <u>pallida</u>	36
4. <u>Coenonympha hero</u> L. X <u>Coenonympha arcania</u> L.	33
5. <u>Dira clytus</u> L. X <u>Dira mintha</u> Geyer	20
6. <u>Chlosyne neumoegeni</u> (Skinner) X <u>Chlosyne californica</u> (Wright)	70
7. <u>Limnitis archippus</u> Cr. X <u>Limnitis astyanax</u> F.	64
8. <u>Lycaena thoe</u> Guerin-Meneville X <u>Lycaena phlaeas</u> <u>americana</u> Harris	85
9. <u>Plebejus icarioides</u> (Bdv.) X <u>Plebejus melissa</u> (Edw.)	25
different genera:	
1. <u>Maniola jurtina</u> L. X <u>Aphantopus hyperantus</u> L.	48
2. <u>Maniola jurtina</u> L. X <u>Minois dryas</u> Scopoli	48
3. <u>Pyronia tithonus</u> L. X <u>Aphantopus hyperantus</u> L.	89 (p. 149)
4. <u>Pyronia tithonus</u> L. X <u>Lasiommata megera</u> L.	17
5. <u>Fabriciana adippe</u> Schiff. X <u>Argynnis paphia</u> L.	34, 57
6. <u>Chlosyne gorgene carlota</u> Reakirt X <u>Polydrias pola arachne</u> Edw.	109
7. <u>Vanessa atalanta</u> (L.) X <u>Aglais urticae</u> L.	73
8. <u>Plebejus icarioides montis</u> Blackmore X <u>Everses amyntula</u> (Bdv.)	32
9. <u>Lysandra coridon</u> Poda X <u>Polyommatus icarus</u> Rott.	99
10. <u>Callophrys dumetorum</u> (Bdv.) X <u>Incisalia iroides</u> (Bdv.)	107
different families:	
1. <u>Aglais urticae</u> L. X <u>Maniola jurtina</u> L.	94
2. <u>Argynnis paphia</u> L. X <u>Quercusia quercus</u> L.	38
3. <u>Chlosyne acastus</u> (Edw.) X <u>Lycaena cupreus snowi</u> Edw.	25
4. <u>Maniola jurtina</u> L. X <u>Mesoacidalia aglaja</u> L.	29, 48
5. <u>Mesoacidalia aglaja</u> L. X <u>Mesoacidalia aglaja</u> L. <u>Maniola jurtina</u> L.	61
6. <u>Maniola jurtina</u> L. X <u>Aglais urticae</u> L.	33, 48, 106
7. <u>Lycaena dispar</u> Haworth X <u>Pieris brassicae</u> L.	109
butterfly X moth (male X female):	
1. <u>Anthracaris cardamines</u> L. X <u>Bapta tenerata</u> (W. V.)--white geometrid 76	
2. <u>Erynnis tages</u> L. X <u>Ectypa glyphica</u> L. --brown noctuid	19
intra-sex (male-male):	
1. <u>Maniola jurtina</u> L. X <u>Minois dryas</u> Scopoli	29
2. <u>Brenthis daphne</u> Schiff. X <u>Mellicta athalia</u> Rott.	74

TABLE 4 Mating time records for butterflies

Species	Times	Sources
PAPILIONIDAE		
Papilioninae		
<u>Battus philenor hirsuta</u> (Skinner)	10:50	69
<u>Papilio eurymedon</u> Lucas	11:20, 11:35, 12:05, 12:34, 12:54, 1:22, 1:34	69
<u>Papilio indra pergamus</u> H. Edwards	between 9:00-9:30, ca. 12:00	69
<u>Papilio machaon</u> L.	1-2	71
<u>Papilio multicaudatus</u> Kirby	2-3	71
<u>Papilio polyxenes</u> Fabr.	ca. 4:30	28
<u>Papilio rudkini</u> (J. A. Comstock)	12:40, 12:45	69
<u>Papilio zelicaon</u> Lucas	See Table 6	69
PIERIDAE		
Pierinae		
<u>Anthocaris cethura</u> (Felder and Felder)	11:42 (see also Table 7)	69
<u>Aporia crataegi</u> L.	10:30, 3:00, ca. 3:15, 4:30	77
<u>Appias drusilla</u> (Cramer)	2:25	56
<u>Catacticta nimbice</u> (Bdv.)	12:30	56
<u>Pieris beckerii</u> Edwards	12:20	69
<u>Pieris napi</u> L.	between 10:55-11:20, 1:00(2), 2:15, 2:30, 3:00 (2), bet. 3-4 (2), 3:30, 4:00 (2), 4:30, 5:30 (2)	69, 77 69
<u>Pieris occidentalis</u> Reakirt	12:00	69
<u>Pieris protodice</u> Bdv. and LeC.	8:00, 8:54, 9:30, 9:30-10:00 (many), 10:58, 12:35, 1:55, 1:58	28, 56, 69, 83
<u>Pieris rapae</u> L.	bet. 10-12, 10:30, 10:45, 11:35, 1:00, 2:00, bet. 2-4, 2:30, 3:00, 3:35, 3:45, 4:30, 5:00, 5:30, 6:00pm	56, 77 69
<u>Pieris sisymbrii</u> Bdv.	9:20, 11:45, 2:30, 2:33	69
<u>Pieris virginianensis</u> Edw.	1:20, 1:30	56
Coliadinae		
<u>Colias croceus</u> Fourcroy	ca. 2:30	56
<u>Colias eurytheme</u> Bdv.	1:05, 1:25	69
<u>Colias hyale</u> L.	ca. 2:30-2:45(2), 3:15	77
<u>Colias meadii</u> Edw.	8:45	69
<u>Colias occidentalis chrysomelas</u> H. Edwards	12:13	69
<u>Eurema daira</u> (Godart)	2:40	56
<u>Eurema lisa</u> Bdv. and LeC.	10:55, 12:55, 1:45	56
<u>Eurema nicippe</u> (Cramer)	11:20	69
<u>Gonepteryx rhamni</u> L.	bet. 1-3	77
<u>Nathalis iole</u> Bdv.	3:50	69
<u>Phoebis sennae</u> (L.)	10:45	69
<u>Zerene cesonia</u> (Stoll)	10:35, 4:20	69
SATYRIDAE		
Satyrinae		
<u>Aphantopus hyperantus</u> L.	10:00(2), 4:00	77
<u>Cercyonis pegala pegala</u> (Fabr.)	1:30	56
<u>Cercyonis pegala boopis</u> (Behr)	10:00	69
<u>Cercyonis pegala maritima</u> (Edw.)	1:00	56
<u>Coenonympha tullia californica</u> (Westw.)	9:06, 10:50, 12:20	69
<u>Erebia callias</u> Edw.	12:45	69
<u>Erebia medusa</u> Schiff.	5:00	77
<u>Euptychia cymela</u> (Cramer)	12:45, 1:30, 2:00	56
<u>Euptychia hermes</u> (Fabr.)	1:30	56

TABLE 4 (cont.)

Species	Times	Sources
<u>Lasiommata megera</u> L.	10:00, 12:00, 1:30, 3:00(2) 4:00(2), 6:00pm, "late after- noons"	77, 89
<u>Maniola jurtina</u> L.	10:15, bet. 1:30-3:00(2), 2:00, 2:15, 2:30, 3:00(2)	56, 77
<u>Melanargia galathea</u> L.	7:15, 9:30, 10:00	77
<u>Minois dryas</u> Scopoli	11:30, 1:30(2), 2:45, 3:00(3)	77
<u>Oeneis melissa lucilla</u> Barnes and McDunnough	11:45	69
<u>Pierella helvina incanescens</u> Godman and Salvin	11:00	56
<u>Pierella luna</u> (Fabr.)	11:00	56
NYMPHALIDAE		
Danainae		
<u>Danaus gilippus strigosus</u> (Bates)	"afternoon" (2pr.), 3:30, 4:40, 5:15	56, 69
<u>Danaus plexippus</u> (L.)	7:25, 12:30, 12:55, 3:30, 4:30-4:45 (12-15 prs.), "afternoon".	56, 69
Nymphalinae		
<u>Adelpha bredowii</u> Geyer	2-3	71
<u>Aglais urticae</u> L.	2-3	71
<u>Anartia fatima</u> (Fabr.)	bet. 10-12	56
<u>Anartia jatrophae luteipicta</u> Fruh.	11:00	56
<u>Argynnis paphia</u> L.	usually at ca. 10; ca. 11:15, bet. 2-3, 3:00, 6:00 pm	77, 100
<u>Asterocampa leila</u> (Edw.)	11:00	56
<u>Chlosyne californica</u> (Wright)	10:30	69
<u>Chlosyne damoetas damoetas</u> (Skinner)	12:45	69
<u>Chlosyne damoetas malcolmi</u> (J. A. Comstock)	9:35	69
<u>Chlosyne gabbii</u> (Behr)	12:30, 1:05, 1:40	69
<u>Chlosyne leanira fulvia</u> (Edw.)	1:30	69
<u>Euphydryas chalcedona</u> (Doubleday)	10:10, bet. 11:30-12:00 (3) 11:19, 12:01, 12:06, 12:56, ca. 2:00, 3:03	69
<u>Euphydryas editha</u> (Bdv.), ssp.	10:30	69
<u>Euphydryas editha baroni</u> (Edw.)	10:30	69
<u>Euptoieta claudia</u> (Cramer)	10:30, 11:10, 11:20, 3:45	56, 69
<u>Inachis io</u> L.	2-3	71
<u>Issoria lathonia</u> L.	ca. 4:15	77
<u>Junonia coenia</u> (Hubner)	1:13	69
<u>Microtia dymas</u> Edw.	12:00, 12:10	69
<u>Nymphalis antiopa</u> L.	2-3 (2)	71
<u>Nymphalis polychloros</u> L.	2-3	71
<u>Phyciodes campestris campestris</u> (Behr)	12:00	69
<u>Phyciodes campestris camillus</u> Edw.	12:20	69
<u>Phyciodes mylitta</u> (Edwards)	10:30, 1:30	69
<u>Phyciodes phaon</u> (Edwards)	10:00	56
<u>Phyciodes tharos</u> (Drury)	12:00, bet. 1-2	56
<u>Polygonia c-album</u> L.	2-3	71
<u>Speyeria aphrodite</u> (Fabr.)	12:30	56
<u>Speyeria callippe callippe</u> (Bdv.)	11:09, 11:17	69
<u>Speyeria callippe comstocki</u> (Gunder)	10:50	69
<u>Speyeria callippe harmonia</u> dos Passos and Grey	10:25	69
<u>Speyeria cybele leto</u> (Behr)	11:30	69
<u>Speyeria egleis</u> (Behr), ssp.	10:15, 11:00, 11:55	69
<u>Speyeria hydaspe</u> (Bdv.)	10:30	69
<u>Speyeria mormonia arge</u> (Strecker)	1:20	69
<u>Speyeria nokomis nokomis</u> (Edw.)	1:05, 2:30	56, 69
<u>Speyeria nokomis apacheana</u> (Skinner)	bet. 12:30-1:30 (4)	69
<u>Speyeria nokomis nitocris</u> (Edw.)	bet. 11-1	28

TABLE 4 (cont.)

Species	Times	Sources
<u>Vanessa atalanta</u> L.	4:15	71
<u>Vanessa cardui</u> (L.)	3:33, 6 pm, 7:30pm	71, 83, 89
<u>Vanessa carye</u> Hubner	3:13	83
LIBYTHEIDAE		
Libytheinae		
<u>Libytheana bachmannii</u> (Kirtland)	10:05 pm, 10:35 pm(2), 11:15 pm, 11:45 pm, (at U- V light)	42
LYCAENIDAE		
Riodininae		
<u>Apodemia mormo mormo</u> (Felder and Felder)	2:05	69
<u>Apodemia mormo virgulti</u> (Behr)	12:13, 12:28	69
Lyceninae		
<u>Callophrys dumetorum</u> (Bdv.)	10:10, 10:18, 10:40	69, 83
<u>Callophrys viridis</u> (Edw.)	1:10, 1:53	69
<u>Callophrys lemberti</u> Tilden	1:50	69
<u>Chrysophanus titus</u> (Fabr.)	bet. 12-2	56
<u>Celastrina argiolus echo</u> (Edwards)	10:26, 11:55, 12:10, 1:28	69
<u>Celastrina argiolus pseudargiolus</u> (Bdv. and LeC.)	bet. 11:30-1:30	56
<u>Everes amyntula</u> (Bdv.)	11:20	69
<u>Everes comyntas</u> (Godart)	6:30 pm	56
<u>Everes comyntas texanus</u> Chermock	bet. 11-1(2), 3:05	56
<u>Hypaurotis crysalus</u> (Edw.)	bet. 7:00-7:40 pm (2)	11
<u>Incisalia henrici</u> (Grote and Robinson)	10:30	16
<u>Incisalia iroides</u> (Bdv.)	bet. 3:00-3:42, 4:15, 4:20(2), 4:30	67, 68
<u>Leptotes marina</u> (Reakirt)	10:21	69
<u>Lycaena arota</u> (Bdv.)	9:30, 1:26	69
<u>Lycaena editha</u> (Bdv.)	10:50	69
<u>Lycaena phlaeas americana</u> Harris	1:15	56
<u>Maculinea arion</u> L.	10:00	77
<u>Mitoura nelsoni muiroi</u> (H. Edw.)	2:50	69
<u>Mitoura loki</u> (Skinner)	1:50	69
<u>Philotes battoides</u> (Behr), ssp.	9:40, 10:27, 11:10(2), 11:15, 11:25, 11:30, 1:05, 1:20, 1:55, 2:20, 2:30, 2:35, 2:40, 2:55	69
<u>Philotes battoides intermedia</u> Barnes and McDunnough	1:15(2)	69
<u>Philotes enoptes ancilla</u> Barnes and McDunnough	9:15, 3:10, 3:25, 3:55	69
<u>Philotes enoptes dammersi</u> Comstock and Henne	10:15, 10:20, 10:25(2), 10:40, 10:50, 2:30	69
<u>Philotes enoptes smithi</u> Mattoni	1:10	69
<u>Philotes rita rita</u> (Barnes and McDunnough)	11:50	69
<u>Philotes rita</u> (Barnes and McD.), ssp.	1:18, 1:25, 1:45, 2:07, 2:10, 4:20	69
<u>Philotes rita pallescens</u> Tilden and Downey	10:40, 1:35, 2:00	69
<u>Philotes sonorensis</u> Felder and Felder	1:25	69
<u>Plebejus acmon</u> (Westw. and Hew.)	10:10, 10:30, 12:00, 1:15(2)	
	1:20, 1:50, 2:12, 2:50	69
<u>Plebejus argus</u> L.	bet. 1-2	77
<u>Plebejus argyrognomon anna</u> (Edw.)	1:10	69
<u>Plebejus argyrognomon ricei</u> (Cross)	1:40	69
<u>Plebejus melissa</u> (Edw.)	2:00	56

TABLE 4 (cont.)

Species	Times	Sources
<u>Plebejus saepiolus</u> (Bdv.)	11:30	69
<u>Plebejus shasta</u> (Edw.)	12:30, 12:50, 2:50	69
<u>Polyommatus icarus</u> Rott.	2:30, 3:00	77, 89
<u>Satyrrium acadica</u> (Edw.)	"evening", 6-7pm, (several) 6-8 pm (several)	11, 56
<u>Satyrrium sylvinus</u> (Bdv.)	bet. 3:30-3:45 (2)	69
<u>Strymon melinus</u> Hubner	bet. 10:10-10:45 pm (at U-V light)	42
HESPERIIDAE		
Hesperinae		
<u>Atrytonopsis hianna</u> (Scudder)	bet. 11-2	81
<u>Hesperia columbia</u> (Scudder)	2:15	54
<u>Hesperia harpalus leussleri</u> Lindsey	12:45	69
<u>Hesperia juba</u> (Scudder)	1:30	69
<u>Hylephila phyleus</u> (Drury)	ca. 4	56
<u>Ochlodes sylvanoides</u> (Bdv.)	9:35	69
<u>Polites peckius</u> (Kirby)	3:20, 4:20	56
<u>Thymelicus sylvestris</u> Poda	10:15, bet. 1:30-3:00 (2)	56, 77
Pyrginae		
<u>Cogia calchas</u> (Herrich-Schaffer)	3:30	56
<u>Erynnis brizo lacustra</u> (Wright)	12:28	69
<u>Erynnis funeralis</u> (Scudder and Burgess)	1:57, 4:33	69
<u>Erynnis juvenalis</u> (Fabr.)	1:20, 2:00, 4:00	56
<u>Erynnis tristis</u> (Bdv.)	11:43, 12:18; see also Table 8	69
<u>Pholisora catullus</u> (Fabr.)	10:15	69
<u>Pholisora libya</u> (Scudder)	9:40	69
<u>Polythrix asine</u> (Hewitson)	bet. 11-12	56
<u>Pyrgus communis</u> (Grote)	11:42, 2:05	69

Includes time that in copulo pairs encountered and time that unattached females of hilltopping species at summits. The sources that designated Standard Time or Daylight Savings Time (all converted to Standard Time here) include 11, 28, 42, 67, 68, 69, 83, 89; not so designated include 16, 54, 56, 71, 77, 81, 100. Number of pairs (if more than one) in parentheses. Times are am(morning) to pm (afternoon) unless designated "pm" (evening).

TABLE 5. Mating times; carrying pairs; virgin female appearance times at hilltops (observed by OS unless otherwise indicated)

I. PAPILIONIDAE

Papilioninae

1. Battus philenor hirsuta (Skinner). 3rd mi. E. of Berryessa Reservoir; Yolo Co., Calif., III-14-72 (A. Shapiro and O. Shields), 10:50 am. (PST), ♀ up, ♂ down.
2. Papilio polyxenes Fabricius. Gates Pass, near Tucson, Ariz., II-24-63 (R. W. Breedlove), ♀ carried ♂.
3. Papilio rudikini (J. A. Comstock). Ca. 4 mi. E. of Jacumba, 3200', San Diego Co., Calif., III-27-66, 2 in cop. pairs: 12:40 and 12:45 p. m. (PST), ♀ carried ♂ in both.
4. Papilio zelicaon Lucas (see Table 6).
5. Papilio indra pergamus H. Edwards. Tecate Mt. summit, San Diego Co., Calif., V-30-64 (S. K. Dvorak), ca. 12:00 pm. (PST); V-16-67 (R. W. Breedlove), between 9:00-9:30 am. (PST).
6. Papilio eurymedon Lucas. a. Dictionary Hill summit, 1064', Spring Valley, San Diego Co., Calif., II-5-67, fresh virgin ♀, 11:20 am. (PST); III-12-67, fresh virgin ♀, 12:34 pm. (PST); IV-22-67, fresh virgin ♀, 12:54 pm. (PST); II-22-68, fresh virgin ♀, 1:22pm. (PST). b. Summit of Hill 997', 1.7 mi. SSE of El Cajon P. O., San Diego Co., Calif., II-6-67, worn virgin ♀, 11:35 am. (PST). c. Cowles Mountain summit, San Diego Co., Calif., VI-6-67, fresh virgin ♀, 12:05 pm. (PST). d. Monument Peak summit, Laguna Mts., San Diego Co., Calif., V-7-67, fresh virgin ♀, 1:34 pm. (PST).

II. PIERIDAE

A. Pierinae

1. Pieris beckerii Edwards. Ca. 5 1/2 mi. N. of Mountain Home, at turnoff to Yellowstone Creek, along Lake Fork Creek, Duchesne Co., Utah, VIII-17-69 (JFE and OS), 12:20 pm. (MST), ♂ carried ♀.
2. Pieris sisymbrii Boisduval. a. Del Puerto Canyon, 1700', 18 road mi. W. of Patterson, Stanislaus Co., Calif., III-7-70 (D. Bragg, R. F. Denno, E. E. Grissell, and OS), 2:30 pm. (PST), ♂ carried ♀. b. Canyon 1 air mi. W. of Mexican Mine, 4600-4800', near Mitchell Caverns State Park, Providence Mts., S. 24, T. 10N., R. 14E., San Bernardino Co., Calif., III-25-70 (JFE and OS), 9:20 am. (PST), ♂ carried ♀, flying on slope near wash, from bush to bush. c. Hill W. of road, ca. 1 road mi. S. of jct. Whitney Portal Rd. and Tuttle Creek-Lone Pine Rd., W. of Lone Pine, Alabama Hills, Inyo Co., Calif., III-28-70 (JFE and OS), 11:45 am. (PST), ♂ carried ♀, on ridge crest. d. Canyon just W. of Devil's Gulch, S.-facing slope of Snyder Ridge above Skelton Creek, Mariposa Co., Calif., III-29-70 (JFE and OS), 2:33 pm. (PST), ♂ carried ♀, along jeep trail on canyon slope.
3. Pieris protodice Boisduval and Le Conte. a. 3 mi. SW of Warner Hot Springs, San Diego Co., Calif., X-17-65, many mating pairs in dry field, between 9:30-10:00 am (PST). b. 841' hill summit, near Dictionary Hill, Spring Valley, San Diego Co., Calif., I-9-67, 1:55 pm. (PST), ♂ carried ♀; c. Dictionary Hill summit, 1064', Spring Valley, San Diego Co., Calif., I-27-67, 1:58 pm. (PST), ♂ carried ♀; V-28-65, ♂ carried ♀. d. Summit of Desert Butte, 2822', Los Angeles Co., Calif., III-23-68 (JFE), 12:35 pm. (PST).
4. Pieris occidentalis Reakirt. North Schell Peak and ridge to NW, Schell Creek Range, 11,000-11,883', White Pine Co., Nev., VIII-1-69 (JFE and OS), 12:00 pm. (PST).
5. Pieris napi (Linnaeus). Bog at Gothic, Gunnison Co., Colo., VII-6-67 (JFE and OS), between 10:55-11:20 am. (MST), ♂ carried ♀.
6. Anthocaris cethura (Felder and Felder) (see also Table 7). Tecate Mt. summit, San Diego Co., Calif., IV-9-67, fresh virgin ♀, 11:42 am. (PST), 56° F., 76% R.H.

TABLE 5 (cont.)

B. Coliadinae

1. Colias meadii Edwards. Cumberland Pass, 12,000', Gunnison Co., Colo., VII-28-67 (JFE and OS), 8:45 am. (MST).
2. Colias eurytheme Boisduva 1. a. Davis, Yolo Co., Calif., X-5-69 (R. F. Denno and OS), 1:05 pm. (PST), ♂ carried ♀. b. Thompson Canyon, just NE of Monticello Dam, Yolo Co., Calif., IV-9-69, 1:25 pm. (PST), ♂ carried ♀ (albinic).
3. Colias occidentalis chrysomelas H. Edwards. Canyon Creek Canyon, ca. 3 mi. SE of Ochoco Ranger Station, Ochoco Mts., Crook Co., Ore., VII-10-70 (S. K. Dvorak and OS), 12:13 pm. (PST), ♂ carried ♀.
4. Zerene cesonia (Stoll). a. Box Canyon (near bridge), Santa Rita Mts., Pima Co., Ariz., VIII-29-70 (S. L. Ellis, OS, and M. E. Toliver), 4:20 pm. (MST), ♂ carried ♀. b. Proctor Ranch, lower end of Madera Canyon, Pima Co., Ariz., IX-21-70 (D. P. Levin and OS), 10:35 am. (MST), ♂ carried ♀.
5. Phoebis sennae (Linnaeus). Proctor Ranch, lower end of Madera Canyon, Pima Co., Ariz., IX-21-70 (D. P. Levin and OS), 10:45 am. (MST), ♂ carried ♀ 4 X.
6. Eurema nicippe (Cramer). 13 road mi. N. of Lemitar, at La Joya State Game Refuge exit of Hwy. 25, Socorro Co., N. M., VIII-21-70 (S. L. Ellis, OS, and M. E. Toliver), 11:20 am. (MST), ♂ carried ♀ (♀ with wet, fully-expanded wings, incapable of flight).
7. Nathalis iole Boisduval. Box Canyon (near bridge), Santa Rita Mts., Pima Co., Ariz., VIII-29-70 (S. L. Ellis, OS, and M. E. Toliver), 3:50 pm. (MST), ♂ carried ♀.

III. NYMPHALIDAE

A. Satyrinae

1. Coenonympha tullia californica (Westwood). a. 1/2 mi. E. of Briceburg, along old RR bed, Mariposa Co., Calif., IV-11-70 (J. Mori and OS), 12:20 pm. (PST), ♀ carried ♀, flew rapidly for ca. 100 yards high in air, alighted in tree once then alighted in weeds. b. N.-facing slope 1.0 air mi. W. of Yellow Bluff, 700-850', Fort Baker Military Res., S. of Sausalito, Marin Co., Calif., IV-18-70 (JFE), 9:06 am. (PST), ♀ carried ♂. c. Thompson Canyon, just NE of Montrello Dam, W. of Winters, Yolo Co., Calif., VI-16-71, 10:50 am. (PST), ♀ carried ♂.
2. Cercyonis pegala boopis (Behr). Canyon Creek Canyon, ca. 3 mi. SE of Ochoco Ranger Station, Ochoco Mts., Crook Co., Ore., VII-16-70 (S. K. Dvorak and OS), 10:00 am. (PST), ♀ carried ♂.
3. Oeneis melissa lucilla Barnes and McDunnough. Cottonwood Pass, Chaffee Co., VII-28-67 (JFE and OS), 11:45 am. (MST).
4. Erebia callias Edwards. Guanella Pass, 11,700-11,800', 11 road mi. S. of Georgetown, Clear Creek Co., Colo. VIII-25-68 (JFE and OS), 12:45 pm. (MST).

B. Danainae

1. Danaus plexippus (Linnaeus). a. Ash Creek Spring, 3800', W. of Las Vegas, Clark Co., Nev., VIII-31-67 (JFE and OS), 7:25 am. (PST), ♂ carried ♀. b. Sand dunes W. of intersection of Palm Ave. and Lake Dr., Marina Beach, Monterey Co., Calif., III-21-70 (JFE and OS), ca. 12:30 pm. (PST), long, high flight seen. c. 1/2 air mile N. of Monticello Dam, Yolo Co., Calif., IV-18-70 12:55 pm. (PST), ♂ carried ♀, inspected after alighted low in tree after flight over open slope, both sexes worn. d. Paradox Creek, 1/2 mi. S. of Paradox, Montrose Co., Colo., VIII-8-70 (S. L. Ellis and OS), 3:30 pm. (MST), ♂ carried ♀ 3X. e. Ca. 1 mi. NW of Carrizozo, Lincoln Co., N. M., VIII-21-70 (S. L. Ellis, OS, and M. E. Toliver), 4:30-4:45 pm. (MST), 8 pairs, ♂ carried ♀ in all, mostly flying around and alighting on E. side of 4 tamarisk trees at roadside, about 12-15 pairs seen altogether.
2. Danaus gilippus strigosus (Bates). a. Ash Creek Spring, 3773', W. of Las Vegas, Clark Co., Nev., VI-25-68 (JFE and OS), 4:40 pm. (PST), ♂ carried ♀. b. Proctor Ranch, lower end of Madera Canyon, Pima Co., Ariz., VIII-28-70 (S. L. Ellis, OS, and M. E. Toliver), 5:15 pm. (MST), ♂ carried ♀.

TABLE 5 (cont.)

C. Nymphalinae

1. Junonia coenia (Hubner). Thompson Canyon, just NE of Monticello Dam, W. of Winters, Yolo Co., Calif., IV-4-71, 1:13 pm. (PST), ♀ carried ♂ 3 X, a long dirt road in canyon bottom where ♂♂ territorial.
2. Euptoieta claudia Cramer. a. 1-4 road mi. N. of Lincoln Nat. For. boundary, on road to El Paso Gap, Eddy Co., N. M., VIII-23-70 (S. L. Ellis, OS, and M. E. Toliver), 11:20 am. (MST), ♂ carried ♀. b. 2 road mi. NE of Oracle Junction, Pinal Co., Ariz., VIII-30-70 (S. L. Ellis and OS), 11:10 am. (MST), ♀ carried ♂. c. Ca. 4 road mi. NNW of Dewey, rd. between Hwy. 69 and 89A, Yavapai Co., Ariz., IX-19-70 (D. P. Levin, L. M. Martin, and OS), 3:45 pm. (MST), ♀ carried ♂.
3. Speyeria nokomis (Edwards). Ca. 5 1/2 mi. N. of Mountain Home, at turnoff to Yellowstone Creek, along Lake Fork Creek, Duchesne Co., Utah, VIII-17-69 (JFE and OS), 1:05 pm. (MST), ♂ perched up, ♀ hanging down, in wet meadow.
4. Speyeria nokomisapacheana (Skinner). Pine Creek Road, Round Valley, Inyo Co., Calif., VIII-27-65 (JFE and OS), 4 in copulo pairs, between 12:30-1:30 pm. (PST), ♂♂ carried ♀♀.
5. Speyeria cybele leto (Behr). Crocker Ridge, ca. 7 air mi. SSW of Mather, Tuolumne Co., Calif., VIII-3-65, 11:30 am. (PST), ♂ carried ♀.
6. Speyeria mormonia arge (Strecker). a. Carnegie Experimental Garden, Slate Creek Valley, 10,000', Mono Co., Calif., VIII-9-64, ♀ carried ♂. b. NW above Tioga Pass, Mono Co., Calif., VIII-22-65, 1:20 pm. (PST), ♂ carried ♀.
7. Speyeria egleis (Behr) ssp. a. Jarbidge Peak summit, 10,789', Jarbidge Mts., Elko Co., Nev., VII-22-69 (JFE and OS), 11:55 am. (PST). b. Bald Mtn. summit, 11,562', N. end of Snake Range, White Pine Co., Nev., VII-30-69 (JFE and OS), 2 in copulo pairs: 10:15 am. (PST), ♀ carried ♂, and 11:00 am. (PST).
8. Speyeria callippe callippe (Boisduval). NE-facing slope 0.4 air mile SSW of Midway Village School, on hilltop at 400', above Guadalupe Canyon Parkway, San Bruno Mts., San Mateo Co., Calif., VII-4-71 (JFE), 2 in copulo pairs: 11:09 am. and 11:17 am. (PST), ♀ carried ♂ in both.
9. Speyeria callippe comstocki (Gunder). Cowles Mt. summit, San Diego Co., Calif., VI-6-67, 10:50 am. (PST), ♀ carried ♂, 67° F., 71°/°. R. H.
10. Speyeria callippe harmonia dos Passos and Grey. North Schell Peak and ridge to NW, Schell Creek Range, 11,000-11,883', White Pine Co., Nev., VIII-1-69 (JFE and OS), 10:25 am. (PST).
11. Speyeria hydaspe (Boisduval) ssp. 7.2 road mi. E. of Parker Mtn. Pass, along Hwy. 66, Klamath Co., Ore., VII-8-70 (S. K. Dvorak and OS), 10:30 am. (PST), ♀ carried ♂.
12. Euphydryas editha (Boisduval) ssp. Bunker Hill and ridge to the SW, 10,000-11,474', Toiyabe Range, Lander Co., Nev., VII-11-69 (JFE and OS), 10:30 am. (PST).
13. Euphydryas editha baroni (Edwards). MacDonald Ranch, 4 road mi. S. of Pope Valley, Napa Co., Calif., V-15-69 (OS and R. Wells), 10:30 am. (PST), on bush in firebreak on a slope.
14. Euphydryas chalcedona (Doubleday). a. Dictionary Hill summit, 1064', Spring Valley, San Diego Co., Calif., II-26-67, fresh virgin female, 11:19 am. (PST); IV-17-67, in copulo pair on bush, ♀ l'horizontal, ♂ down, 10:00 am. (PST), ♀ carried ♂, 63° F., 69°/°. R. H.; IV-27-67, worn virgin female, 12:56 pm. (PST); V-6-67, in copulo pair horizontal on weed, 12:01 pm. (PST) b. Tecate Mt. summit, San Diego Co., Calif., IV-9-67, fair virgin female, 12:06 pm. (PST). c. Ravine 0.3 air mi. SE of highest peak, 1050', on NE slope of San Bruno Mts., San Mateo Co., Calif., IV-8-70 (JFE), 3:03 pm. (PST), ♀ carried ♂. d. 2 air mi. NW of jcts. of Bear Valley Rd. and Hwy. 20, near Wilbur Springs, Colusa Co., Calif., IV-25-70 (R. F. Denno), ca. 2:00 pm. (PST), ♀ carried ♂, along road. e. 1/2 air mi. E. of Briceburg, along old RR bed, Mariposa Co., Calif., IV-25-70 (J. Mori), between 11:30-12:00 am. (PST), 3 in copulo pairs, ♀ carried ♂ in all.

TABLE 5 (cont.)

15. Microtia dymas Edwards. Proctor Ranch, lower end of Madera Canyon, Pima Co., Ariz., IX-21-70 (D. P. Levin and OS), 2 pairs; 12:00 and 12:10 pm. (MST), ♀ carried ♂ in both.
16. Chlosyne damoetas (Skinner). Cottonwood Pass, Chaffee Co., Colo., VII-28-67 (JFE and OS), 12:45 pm. (MST).
17. Chlosyne damoetas malcolmi (J. A. Comstock). Above Upper Gaylor Lake, NW of Tioga Pass, Tuolumne Co., Calif., VIII-29-65 (JFE and OS), 9:35 am. (PST), ♀ carried ♂.
18. Chlosyne gabbii (Behr). Sand dunes W. of Marina, 60-100', Monterey Co., Calif., V-9-70 (JFE and OS), 3 in copulo pairs: 12:30 pm., 1:05 pm., and 1:40 pm. (PST), ♀ carried ♂ in all.
19. Chlosyne leanira fulvia (Edwards). Ca 1 mi. SW of Placitas, along Hwy. 44, Sandoval Co., N. M., VIII-17-70 (S. L. Ellis and OS), 1:30 pm. (MST), ♀ carried ♂.
20. Chlosyne californica (Wright). Bonanza King Mine Canyon, E. side Providence Mts., San Bernardino Co., Calif., IX-17-70 (D. P. Levin and OS), 10:30 am. (PST), ♀ carried ♂.
21. Phyciodes mylitta (Edwards) a. 4.3 road mi. S. of jct. of Tolman Creek Rd. and Ashland St., just S. of Ashland, Jackson Co., Ore., VII-8-70 (S. K. Dvorak and OS), 1:30 p.m. (PST), ♀ carried ♂, ♀ feeding on yarrow flowers. b. Thompson Canyon, just N. E. of Monticello Dam, W. Winters, Yolo Co., Calif., VI-16-71, 10:30 am. (PST), ♀ carried ♂, along dirt road in canyon bottom.
22. Phyciodes compertris (Behr). Carnegie Experimental Garden, 4600', 1 mi. E. of Mather, Tuolumne Co., Calif., VI-23-64, ♀ carried ♂; VII-14-64, ♀ carried ♂; VII-5-65, 12:00pm. (PST), ♀ carried ♂.
23. Phyciodes campestris camillus Edwards. 3.1 mi. W. of junction Colo. Hwy. 149 and U.S. 50, near Iola, Gunnison Co., Colo., VIII-27-67 (JFE and OS), 12:20 pm. (MST).

IV. LYCAENIDAE

A. Riodininae

1. Apodemia mormo (Felder and Felder). 7 road mi. SE of Fredonia, 5000', along highway 89A, Coconino Co., Ariz., VIII-30-69 (JFE and OS), 2:05 pm. (MST).
2. Apodemia mormo virgulti (Behr). Dictionary Hill summit, 1064', Spring Valley, San Diego Co., Calif., III-30-66, 12:13 pm. (PST), ♀ carried ♂, 86° F., 63°/°. R. H.; II-5-67, 12:28 pm. (PST), ♀ carried ♂.

B. Lycaeninae

1. Satyrus sylvinus (Boesduval). Stonyford, Colusa Co., Calif., VI-5-69 (J. Mori and OS), between 3:30-3:45 pm. (PST), 2 in copulo pairs along road where adults abundant on milkweed (see figure 5).
2. Mitoura nelsoni muiri (H. Edwards). About 4 1/2 road mi. SW of jct. of Brim Rd. and Bear Valley Rd., Walker Ridge Public Lands area, SW of Leesville, Lake-Colusa Co. line, Calif., IV-17-72 (OS and S. Sims), 2:50 pm. PST, on cypress during overcast.
3. Mitoura loki (Skinner). Ca. 4 mi. E. of Jacumba, 3200', San Diego Co., Calif., III-27-66, 1:50 pm. (PST), ♀ walked ♂ in her direction when on ground, found on juniper.
4. Callophrys viridis (Edwards). Sand dunes W. of Marina, 60-100', Monterey Co., Calif., V-9-70 (JFE and OS), 2 in copulo pairs: 1:10pm. and 1:53 pm. (PST), in small ravines on Eriogonum latifolium, abdomens forming a 90° angle during mating.

TABLE 5 (cont.)

5. Callophrys dumetorum (Boisduval). Bobs Gap, ca. 6 air mi. SE of Pearblossom, Los Angeles Co., Calif., III-22-70 (C. Henne, JFE, and OS), 10:40 am. (PST), in copulo pair on dried Eriogonum fasciculatum flower, in wash where males territorial and common.
 6. Callophrys lemberti Tilden. 1 mi. S. of Fredericksburg, 5100', Alpine Co., Calif., IV-9-72 (OS and R. Wells), 1:50 pm. (PST).
 7. Lycaena arota (Boisduval). a. Cottonwood Canyon, 7000', S. of Bodie, Mono Co., Calif., VIII-19-65, 9:30 am. (PST), ♂ carried ♀. b. No Name Creek, near Glenwood Springs, Garfield Co., Colo., VIII-24-67 (JFE and OS), 1:26 (MST).
 8. Lycaena editha (Mead). SW side of Lake Spalding, Nevada -Placer Co. line, Calif., ca. 6000', VII-20-65, 10:50 am. (PST), ♂ carried ♀.
 9. Plebejus acmon (Westwood and Hewitson). a. Crocker Ridge, ca. 7 air mi. SSW of Mather, Tuolumne Co., Calif., VIII-3-65, 12:00 pm. (PST), ♂ carried ♀. b. Carnegie Experimental Garden, 4600', 1 mi. E. of Mather, Tuolumne Co., Calif., VIII-7-65, 1:20 pm. (PST), ♀ carried ♂; IX-3-66, 10:30 am. (PST), ♂ carried ♀. c. Skelton Creek, 3400', Jerseydale, 8 1/2 air mi. NE of Mariposa, Mariposa Co., Calif., VIII-1-68, 10:10 am. (PST), ♂ carried ♀. d. Canyon 1 mi. NE of Monticello Dam, Yaca Mts., W. of Winters, Yolo Co., Calif., III-19-70, 2:12 pm. (PST), ♂ carried ♀ 2 X when disturbed. e. Mud Creek, 2000-2200', near Ponderosa Way, SE 1/4 S. 26, T. 24N., R. 2E., Butte Co., Calif., IV-5-70 (JFE, S. O. Mattoon, and OS), 2:50 pm. (PST), ♂ carried ♀. f. Ca. 3 mi. W. of N. Fk. Merced River, 11 road mi. E. of Coulterville, Mariposa Co., Calif., V-29-70 (J. Mori and OS), 1:50 pm. (PST), ♀ carried ♂, alighted, then ♂ carried ♀. g. Near ridge summit W. above Thompson Canyon, N. of Monticello Dam, W. of Winters, Yolo Co., Calif., VII-1-71, 2 in copulo pairs, 1:15 pm. (PST), ♂ carried ♀ in one, ♀ carried ♂ in other (both pairs "flighty"), along road on ridge.
 10. Plebejus shasta (Edwards). W. end of Dana Plateau, 11,000-11,400', above Tioga Pass, Mono Co., Calif., VII-8-69 (JFE and OS), 3 in copulo pairs: 12:50 pm. (PST), ♀ carried ♂, 12:30 pm. (PST), ♂ carried ♀, and 2:50 pm. (PST) on ground.
 11. Plebejus argyrognomon anna (Edwards). W. side of Loon Lake, ca. 15 air mi. N. of Kyburz, El Dorado Co., Calif., VII-25-71 (OS and R. Wells), 1:10 pm. (PST), on Trifolium sp. flower.
 12. Plebejus argyrognomon ricei (Cross). Lost Prairie, SW of Santiam Junction, along Hwy. 20, Linn Co., Ore., VII-17-70 (S. K. Dvorak and OS), 1:40 pm. (PST), ♂ carried ♀.
 13. Plebejus saepiolus (Boisduval). Mendocino Pass, 5000', along road to Covelo, Glenn Co., Calif., VII-3-70 (S. K. Dvorak and OS), 11:30 am. (PST), ♀ carried ♂ when first disturbed, then ♂ carried ♀ many times when further disturbed.
- Genus Philotes -genitically determined by OS: final subspecific placement on some and foodplant determinations will be reported elsewhere in a monograph.
14. philotes sonorensis Felder and Felder. Chili Bar, cal. 1000', ca. 4 road mi. N. of Placerville, on Calif. Hwy. 193, at crossing of South Fork American River, El Dorado Co., Calif., II-22-70 (OS and R. Wells), 1:25 pm. (PST), ♀ horizontal, ♂ slightly down on dried weed 1' from Dudleya cymosa.
 15. Philotes battoides intermedia Barnes and McDunnough. Peak S. of Castle Lake, N.-facing slope, 5600'-6400', Siskiyou Co., Calif., VII-18-68 (JFE and OS), 2 in copulo pairs at 1:15 pm. (PST), on Eriogonum sp.
 16. Philotes battoides oregonensis Barnes and McDunnough. 7/10 mi. SE of jet. of Crater Lake Nat'l Park boundary (S.) and Hwy. 62, on Hwy. 62, Klamath Co; Ore. VII-17-71 (C. Goodpasture, OS, and B. Villegas), 2 in copulo pairs: 12:03 pm, and 12:30 pm. (PST), ♀ carried ♂ in both, on flower-heads of Eriogonum sp; VII-18-71 (same collectors), 2 in copulo pairs: 11:45 am. and 12:15 pm. (PST), on flower-heads of Eriogonum sp.

TABLE 5 (cont.)

17. philotes battoides (Behr) ssp. a. 7-8 road mi. ESE of Fredonia, 5000', along Hwy. 89A, Coconino Co., Ariz., VIII-30-67 (JFE and OS), 5 in copulo pairs: 11:10, 11:10, 11:15, 11:25, and 11:30 am. (MST), associated with Eriogonum sp.; VIII-30-69 (JFE and OS), 5 in copulo pairs: 1:55 pm. (MST), alighting on Eriogonum sp. flowers; 2:20 pm. (MST), ♂ carried ♀; 2:30 pm. (MST), ♂ carried ♀ when disturbed from position of male slightly up from female and facing into sun, horizontal on Artemisia bush; 2:35 pm. (MST), ♂ carried ♀, alighting on Eriogonum sp. flowers; and 2:40 pm. (MST), ♂ carried ♀, landed on twig. b. 1 mi. E. of Glendale, on road to Fourmile Hollow, 6200', Kane Co., Utah, IX-4-68 (JFE and OS), 1:20 pm. (MST), on flower-head of Eriogonum sp. c. 14 road mi. SW of Mexican Hat, 5400', San Juan Co., Utah, IX-3-68 (JFE and OS), 1:05 pm. (MST), on flower-head of Eriogonum sp. d. 9.5 road mi. NE of Winona, on hwy. to Leupp, Coconino Co., Ariz., IX-1-70 (S. L. Ellis and OS), 10:27 am. (MST), on extremity of Eriogonum sp. plant, ♂ carried ♀ when disturbed. e. 7.7 to 8.1 road mi. ENE of Kayenta (from jct. hwy. 464 and 164), just SE of Church Rock, Navajo Co., Ariz., IX-2-70 (S. L. Ellis and OS), 9:40 am. (MST), ♀ carried ♂. f. 11 road mi. NNW of Mexican Hat, base of Cedar Mesa, along Hwy. 261, San Juan Co., Utah, IX-2-70 (S. L. Ellis and OS), 2:55 pm. (MSY), on Eriogonum sp. extremity.
18. philotes enoptes dammersi Comstock and Henne. a. 1 1/2 mi. S. of Banning, 2300', along Hwy. R1, Riverside Co., Calif., IX-10-69 (JFE and OS), 6 in copulo pairs: 10:15, 10:25, 10:25, 10:40, 10:50 am. (PST), all on Eriogonum sp., and 10:20 am. (PST), ♂ carried ♀. b. Mid Hills, 5100', NW exposure of ridge, T. 13N., R. 15E., NE 1/4 of S. 31, along road, San Bernardino Co., Calif., IX-16-70 (D. P. Levin and OS.), 2:30 pm. (PST), on terminal branch of Eriogonum sp., ♂ carried ♀ when disturbed.
19. philotes enoptes smithi Mattoni. Dunes at NW end of Olympia Ave., Seaside, Monterey Co., Calif., VIII-2-70 (D. P. Levin and OS), 1:10 pm. (PST), ♂ carried ♀.
20. philotes enoptes ancilla Barnes and McDunnough. S. - and W. - facing slopes of Victorine Canyon, 8000-10,000', S. side of Bunker Hill, Toiyabe Range, Lander Co., Nev., VII-11-69 (JFE and OS), 4 in copulo pairs: 9:15 am. (PST), on Eriogonum sp.; 3:10 pm. (PST), in flight; 3:25 pm. (PST), in flight; and 3:55 pm. (PST), on Eriogonum sp., ♂ carried ♀ when disturbed.
21. philotes rita pallescens Tilden and Downey. a. SE base of Sand Mountain, 4000', T. 17N., R. 32., ca. 7 air mi. WNW of Frenchman, Churchill Co., Nev., VII-13-69 (JFE and OS), 10:40 am. (PST) on upper part of Eriogonum sp., ♂ carried ♀ when disturbed. b. Sand hills 3 road mi. SW of Johnsons Pass, 5200', E. side of Skull Valley, T. 6S., R. 7W., Tooele Co., Utah, VIII-13-69 (JFE and OS), 2 in copulo pairs: 1:35 and 2:00 pm. (MST), on Eriogonum sp.
22. Philotes rita (Barnes and McDunnough). 18 road mi. WNW of Silver City, along Hwy. 180, Grant Co., N. M., VIII-26-70 (OS and Mj E. Toliver), 11:50 am. (MST), ♂ carried ♀ when disturbed, on Eriogonum sp.
23. philotes rita (Barnes and McDunnough) ssp. a. At SW base of a bluff, 3 road mi. N. and 1 road mi. E. of Bluff, San Juan Co., Utah, VIII-25-69 (JFE and OS), 2 in copulo pairs: 2:07 and 2:10 pm. (MST), vertical and horizontal on stems of Eriogonum sp. b. Poison Spring Canyon, 1 mi. S. of Wayne Co. line, along Hwy. 95, 18 road mi. SE of Hanksville, Garfield Co., Utah, VIII-26-69 (JFE and OS), 1:18 pm. (MST), vertical on stem of Eriogonum sp. c. Summit of road to 1 1/2 mi. E., of Little Flat Top, 5500', T. 26S., R. 14E., ca. 10-11 mi. SE of Utah highway 24, Emery Co., Utah, VIII-26-69 (JFE and OS), 4:20 pm. (MST), vertical on stem of Eriogonum sp., ♂ up, ♀ down. d. 2 1/2 road mi. N. of Joseph City, Navajo Co., Ariz., VIII-31-70 (S. L. Ellis and OS), 1:25 pm. (MST), up on stem of Eriogonum sp. e. 6.8 road mi. SW of Mexican Hat, along Hwy. 163, San Juan Co., Utah, IX-2-70 (S. L. Ellis and OS), 1:45 pm. (MST), on extremity of Eriogonum sp.
24. Everes amyntula (Boisduval). Bog at Gothic, Gunnison Co., Colo., VII-6-67 (JFE and OS), 11:20 am. (MST).
25. Leptotes marina (Reakirt). Dictionary Hill summit, 1064', Spring Valley, San Diego Co., Calif., III-30-67, 10:21 am. (PST), ♀ carried ♂.

TABLE 5 (cont.)

26. Celastrina argiolus (Edwards). a. Tecate Mt. summit, San Diego Co., Calif., IV-9-67, 10:26 am. (PST), 56° F., 65°/. R. H. b. Dictionary Hill Summit, 1064', Spring Valley, San Diego Co., Calif., IV-22-67, Virgin female, 1:28 pm. (PST); V-6-67, 12:10 pm. (PST). c. Monument Peak summit, Laguna Mts., San Diego Co., Calif., VI-12-68, 11:55 am. (PST).

V. HESPERIIDAE

A. Hesperiniinae

1. Ochloides sylvanoides (Boisduval). Jerseydale, 81/2 air mi. NE of Mariposa, Mariposa Co., Calif., IX-2-71, 9:35 am. (PST), ♀ carried ♂ 5 X, in sunlit clearing.
2. polites sonora (Scudder). Carnegie Experimental Garden, 4600', 1 mi. E. of Mather, Tuolumne Co., Calif., VIII-7-64, ♀ carried ♂.
3. Hesperia harpalus leussleri Lindsey. Ravine 1/4 mi. N. of Horse Flats Campground, N. of Chilao Rec. Area, 5900', San Gabriel Mts., Los Angeles Co., Calif., VI-27-70 (S. K. Dvorak and OS), 12:45 pm. (PST), ♀ carried ♂.
4. Hesperia juba (Scudder). Boiling Springs, Laguna Mts., San Diego Co., Calif., IV-30-66, 1:30 pm. (PST), ♀ carried ♂.

B. Pyrginae

1. Pholisora catullus (Fabricius). U. C. Davis, Yolo Co., Calif., VIII-25-71, 10:15 am. (PST), ♀ carried ♂ 2 X, on lawn.
2. Pholisora libya (Scudder). Lovelock-Unionville Road, ca. 4 air mi. NE of Spring Valley, on boundary between sects. 20 and 29, T. 29N. R. 35E., E. side of Humboldt Range, Pershing Co., Nev., VII-19-69 (JFE and OS), 9:40 am. (PST), where adults commonly feeding along roadside.
3. Pyrgus communis (Grote). a. Thompson Canyon, just NE of Monticello Dam, W. of Winters, Yolo Co., Calif., IV-23-70, 11:42 am. (PST), ♀ carried ♂, along road in canyon bottom. b. Footman Ridge summit, E. above Jerseydale, Mariposa Co., Calif., VII-22-71, 2:05 pm. (PST), ♀ carried ♂.
4. Erynnis brizo lacustra (Wright). Ridge crest ca. 3 road mi. W. of jct. of Brim Rd. and Bear Valley Rd., Walker Ridge Public Lands, SE of Leesville, Colusa-Lake Co. line, Calif., V-15-70 (R. F. Denno and OS), 12:28 pm. (PST), ♀ carried ♂, both worn.
5. Erynnis tristis (Boisduval) (See also Table 8). Summit of Hill 997', 1.7 mi. SSE of El Cajon P. O., San Diego Co., Calif., II-6-67, 2 in copulo pairs: 11:43 am. and 12:18 pm. (PST), ♀ carried ♂ in both.
6. Erynnis funeralis (Scudder and Burgess). a. Near "Two Mile Hill", Scissors Crossing, San Diego Co., Calif., II-22-67, 1:57 pm. (PST), ♀ carried ♂ in arroyo. b. Dictionary Hill summit, 1064', Spring Valley, San Diego Co., Calif., VI-14-68, 4:33 pm. (PST).
7. Thorybes diversus Bell. Carnegie Experimental Garden, 4600', 1 mi. E. of Mather, Tuolumne Co., Calif., VI-18-65, ♀ carried ♂.

TABLE 6. Female Papilio zelicaon, collected on the summit of Dictionary Hill
(74 Specimens)

DATE	(PST) TIME	(°F) TEMP.	°/ REL. HUM.	WING CONDITION	BEHAVIOR	SPERM- ATOPHORES
X-24-66	1:34	89	20	fresh	flying	1(new)
X-25-66	2:28	90	20	worn	flying	1(old)
XII-17-66	1:15	67	54	fresh	flying	0
XII-17-66	2:06	69	51	fresh	flying	0
XII-18-66	11:17	68	46	fresh	flying	0
XII-18-66	11:43	68	46	fresh	flying	0
XII-18-66	1:05	74	37	worn	--	1(old)
XII-18-66	2:10	72	35	fresh	flying	0
XII-19-66	12:30	71	34	fresh	flying	0
XII-19-66	1:25	73	39	fresh	courtship	0
XII-19-66	2:22	--	--	worn	flying	1 (large)
XII-24-66	12:35	61	68	fair	flying	0
XII-24-66	1:08	59	78	fresh	flying	0
XII-25-66	11:36	59	78	fresh	flying	0
XII-25-66	12:42	61	68	fresh	flying	0
XII-25-66	12:50	60	73	fresh	flying	0
XII-26-66	12:39	55	65	worn	flying	2 (old)
XII-28-66	11:07	54	48	fresh	flying	0
XII-28-66	1:00	57	47	worn	flying	1 (old)
XII-28-66	1:29	--	--	fresh	flying	0
* XII-31-66	12:50	62	51	fresh	in copulo	1 (new)
XII-31-66	1:58	61	50	fresh	flying	0
I-1-67	12:32	63	51	fresh	in copulo	0
I-7-67	1:14	--	--	worn	flying	0
I-9-67	12:40	65	40	fresh	flying	0
I-14-67	12:05	--	--	fresh	flying	0
I-14-67	12:16	--	--	fresh	flying	0
I-14-67	1:00	71	52	fresh	--	0
I-15-67	11:06	--	--	--	courtship	0
I-15-67	12:10	--	--	worn	flying	3 (2 old, 1 new)
I-15-67	1:00	77	39	fresh	--	0
I-27-67	1:46	--	--	fair	flying	1 (old)
I-28-67	12:06	--	--	fresh	flying	0
II-4-67	12:06	--	--	fresh	--	0
II-4-67	12:16	--	--	fresh	courtship	0
II-4-67	1:10	75	44	fair	--	1(old)
II-4-67	1:11	75	44	fresh	--	0
II-26-67	11:08	60	73	fresh	flying	0
II-26-67	11:38	60	68	fresh	courtship	0
III-5-67	12:08	58	72	worn	--	0
III-16-67	12:17	--	--	worn	courtship	1(old)
III-19-67	11:41	66	70	--	courtship	1(old)
IV-23-67	11:23	61	73	fair	in copulo	0
IV-30-67	12:16	62	69	fresh	flying	0
V-1-67	3:27	69	47	fresh	flying	0
V-4-67	10:09	66	62	fresh	in copulo	0
IX-13-67	12:13	80	57	fair	flying	2 (old)
IX-13-67	12:43	81	61	worn	--	2 (1 old, 1 new)
IX-13-67	2:14	82	62	fresh	flying	1 (new)
IX-28-67	12:37	78	71	fresh	flying	0
IX-28-67	12:59	78	71	fresh	in copulo	1 (new)

TABLE 6 (cont.)

DATE	(PST) TIME	(°F) TEMP.	% REL. HUM.	WING CONDITION	BEHAVIOR	SPERM-ATOPHORES
XII-17-67	1:40	--	--	fresh	in copulo	1 (new)
XII-22-67	12:17	62	37	fresh	in copulo	0
XII-22-67	12:30	--	--	fresh	flying	0
* XII-22-67	12:52	--	--	--	in copulo	1 (new)
XII-23-67	1:39	--	--	worn	flying	0
+ XII-27-67	12:54	--	--	fresh	flying	1 (new)
I-1-68	12:43	--	--	fresh	in copulo	1 (new)
I-11-68	12:21	--	--	fresh	in copulo	1 (new)
I-13-68	12:15	--	--	fresh	in copulo	1 (new)
I-13-68	12:37	--	--	fresh	in copulo	1 (new)
I-13-68	12:37	--	--	worn	in copulo	1 (new)
I-14-68	1:14	--	--	fresh	in copulo	1 (new)
I-21-68	12:15	--	--	fresh	in copulo	0
I-28-68	1:24	--	--	fresh	flying	0
II-2-68	10:30	--	--	fresh	alighted	0
II-19-68	1:37	--	--	fresh	flying	1 (old)
II-22-68	11:29	--	--	--	flying	0
II-23-68	11:43	--	--	fresh	flying	0
II-24-68	11:05	--	--	fresh	--	0
II-24-68	11:15	--	--	worn	--	3
II-24-68	11:39	--	--	--	--	0
II-24-68	12:32	--	--	worn	--	1
III-10-68	1:15	--	--	fresh	in copulo	1 (new)

* = ♀ carried ♀ (2).

+ = female flew off the summit in short "hops" as did females that departed after mating; therefore, she may have just mated.

All in copulo pairs approached had ♀ up, ♂ down, on vegetation, except for several that were horizontal. All "new" spermatophores were freshly deposited, so their transference probably occurred on the summit.

TABLE 7 Female *Anthocaris cethura*, collected on the summit of Dictionary Hill (11 specimens)

DATE	(PST) TIME	(°F) TEMP.	% REL. HUM.	WING CONDITION	BEHAVIOR	SPERM-ATOPHORES
II-20-67	10:20	--	--	fresh	feeding	0
II-28-67	11:02	76	45	--	in copulo	1 (new)
III-5-67	11:37	--	--	fresh	alighted	0
* III-16-67	12:09	77	56	fresh	in copulo	0
IV-22-67	12:41	57	77	fresh	flying	0
IV-23-67	10:01	--	--	fair	flying	0
IV-27-67	10:09	62	84	fresh	alighted	0
V-4-67	9:35	--	--	fresh	flying	0
V-14-67	8:45	76	42	fresh	alighted	0
II-23-68	11:04	--	--	fresh	flying	0
III-21-68	10:50	--	--	--	in copulo	1 (new)

* = ♂ carried ♀; in all 3 in copulo pairs, ♂ up, ♀ down.

TABLE 8. Female Erynnis aristis, collected on the summit of Dictionary Hill (37 specimens)

DATE	(PST) TIME	(°F) TEMP.	(%/.) REL. HUM.	WING CONDITION	BEHAVIOR	SPERM- ATOPHORES
IX-23-66	1:36	90	39	fresh	in copulo	-
I-15-67	12:16	77	39	fresh	flying	0
I-26-67	2:14	--	--	--	courtship	0
II-2-67	11:39	64	61	fresh	in copulo	1 (new)
II-2-67	11:55	66	66	fresh	in copulo	0
II-2-67	12:55	66	62	fresh	in copulo	0
II-2-67	1:18	66	62	fresh	in copulo	0
II-4-67	10:57	68	50	--	courtship	0
II-4-67	12:43	76	42	fresh	in copulo	0
II-4-67	12:43	76	42	fresh	in copulo	1 (new)
II-4-67	12:55	--	--	--	in copulo	0
II-5-67	12:10	62	74	--	in copulo	0
* II-11-67	11:34	76	52	fair	in copulo	1 (new)
* II-11-67	12:07	76	52	fresh	in copulo	1 (new)
II-16-67	1:15	64	56	fresh	in copulo	0
II-22-67	(11:40-	--	--	--	in copulo	1 (new)
II-22-67	11:50)	--	--	--	in copulo	1 (new)
II-26-67	11:45	60	68	fresh	in copulo	0
II-26-67	11:55	60	68	--	in copulo	1 (new)
II-26-67	12:38	63	69	--	in copulo	0
II-26-67	12:38	63	69	--	in copulo	0
II-26-67	12:54	64	65	--	in copulo	1 (new)
II-27-67	11:04	71	45	--	in copulo	1 (new)
II-27-67	11:27	73	60	fresh	in copulo	0
* II-27-67	11:41	--	--	fresh	in copulo	1
II-28-67	11:36	80	38	fresh	in copulo	1 (new)
* III-16-67	10:39	73	54	fresh	in copulo	0
* III-16-67	11:36	76	59	fresh	in copulo	1 (new)
* III-16-67	11:55	76	55	--	in copulo	0
V-14-67	2:27	85	36	--	alighted	0
II-19-68	1:42	--	--	fresh	in copulo	--
II-22-68	11:57	--	--	--	in copulo	0
II-23-68	12:39	--	--	--	in copulo	0
II-23-68	1:07	--	--	--	in copulo	0
II-24-68	12:00	--	--	--	in copulo	0
II-25-68	11:59	--	--	fresh	in copulo	1 (new)
+ II-25-68	12:15	--	--	--	in copulo	0

* = ♀ carried ♂. (7)., + = ♂ carried ♀ (1). All spermatophores were freshly deposited, so their transference probably occurred on the summit; in all (33) in copulo pairs except one on the ground, ♀ above ♂ in resting position.

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IN THIS ISSUE

- A new species of *Papilio*
from the eastern United
States (Papilionidae) J. Richard Heitzman 1
- Specific entities of the subgenus
Icaricia Nabokov (Lycaenidae)
J. W. Tilden 11
- The correct name for the
subspecies of *Limenitis weidemeyerii*
occurring in Arizona (Nymphalidae)
Cyril F. Dos Passos 21
- A review of carrying pair
behavior and mating times in
butterflies
Oakley Shields and John F. Emmel 25

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OF RESEARCH
ON THE LEPIDOPTERA



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THE ECOLOGICAL ASSOCIATIONS OF THE BUTTERFLIES OF STATEN ISLAND

(Richmond County, New York)

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INTRODUCTION

ALTHOUGH THE BUTTERFLIES of the northeastern United States have been studied and collected for a century and a half, an ecologist trying to use published data on them for the analysis and comparison of faunas is apt to find himself at a loss. Intensive regional faunistic studies are few, and published phenological data are scanty; the best regional documentation is tied up in the unpublished notebooks of long-time resident collectors or dispersed with their collections. The lack of such data was brought home when a regional study of the Delaware Valley was in preparation (Shapiro, 1966); a region collected by Skinner, Aaron, Haimbach, Laurent, and others in the forefront of butterfly study in their time was appallingly documented! The Delaware Valley situation, far from being unique, applies to most of the northeast. General regional surveys are available for the state of New Jersey (Comstock, 1949) and the vicinity of Philadelphia (Skinner and Aaron, 1889) and unusually good data for the District of Columbia (Clark, 1932). More or less detailed studies of specific localities have appeared: the McLean Bogs Reserve (Forbes, 1926) and the Allegany State Park (Saunders, 1932) in upstate New York; the Tinicum Wildlife Preserve near Philadelphia (Shapiro, 1970a); and the Powdermill Nature Reserve in southwestern Pennsylvania (Clench, 1958, 1959, 1960). Some ecological and phenological data can be

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extracted from the many local lists published mostly before 1940 in the *Canadian Entomologist*, *Entomological News*, etc. (e.g., Bailey, 1877 for Karner, then Center, New York). The documentation for the New York city area is very poor (cf. Beutenmuller, 1893, 1902).

In 1910, William Thompson Davis published "A List of the Macrolepidoptera of Staten Island, New York," with copious natural history annotations on the butterflies. Davis was an all-around, self-taught naturalist, an indefatigable observer and a stimulating teacher whose influence on Staten Island remains strong twenty-five years after his death. His interest in the butterflies was later supplanted by other specialties, but in those early years he set down on record a vivid picture of the Island and its fauna which allows for comparison with conditions sixty-odd years later.

Until very recently, Staten Island remained relatively undeveloped in the literal shadow of New York City. The building of the Verrazzano-Narrows Bridge, linking the Island to Brooklyn, has ended its isolation and probably doomed its natural features to submergence by asphalt and concrete. Despite its underdevelopedness and proximity to the city, the Island received virtually no attention from Lepidopterists after Davis' active years. Yet Staten Island is of special interest for several reasons: its great geological and botanical diversity within a small area; its location near the northern extremity of the Atlantic coastal plain corridor; its sharing of biotic elements with the distinctive Pine Barrens of southern New Jersey and central Long Island; and the changes and stresses brought on its biota by the work of man. Like the Philadelphia area, Staten Island is geographically strategic in bringing together species from different biomes and hence has a very high species diversity. Cognizant of the need to document this situation before it is obliterated by advancing urbanization, we initiated an ecological survey of the butterflies of Staten Island in the summer of 1970 and continued it through the 1971 season.

Characteristic of the Atlantic seaboard climate is its high interseasonal variance in virtually any property measured. The year 1971 proved to be an extreme one even in a climate of extremes, casting some doubt on the validity of our phenological observations. The nature of the 1971 deviations and their impact on the biology of butterflies are discussed in Appendix II.

Geography and Topography

Staten Island is coextensive with Richmond County, New York, and the Borough of Richmond of the City of New York. It is located between latitude $40^{\circ}29'$ - $40^{\circ}39'$ north and longitude $74^{\circ}3'$ - $74^{\circ}16'$ west, opposite the mouths of the Hudson, Hackensack, Passaic and Raritan Rivers. The Island forms an irregular triangle covering some 70 square miles with maximum dimensions 13 miles (NE-SW) by $7\frac{3}{4}$ miles (NW-SE). The Island is shown in full on the United States Geological Survey 15-minute quadrangle, "Staten Island New York-New Jersey," (1955) and on the 7.5-minute quadrangles "Elizabeth," "Jersey City," "Arthur Kill," and "The Narrows."

The following summary of the topography of Staten Island is from Glazer (1938):

The most marked topographic feature is a central ridge having a fairly uniform range of elevation. It extends in a northeast-southwest direction, from New Brighton to Richmond. To the south, the ridge curves sharply westward and sinks rather suddenly beneath the inundated expanse of Fresh Kills meadows.

The elevation forms a broad belt whose area is approximately 14 square miles. The eastern and southeastern sides are rather sharply defined by an abrupt escarpment, at the foot of which lies a coastal plain extending from lower (New York) and Raritan Bays. The western flanks, on the other hand, are more gently inclined and their outlines are softened beneath a mantle of glacial drift. This gentler inclination may well be due to the low dip of Triassic strata, which boring logs . . . show to have extended at one time to higher altitudes on the west side of the Island.

Upon the ridge as a base there is superimposed a cover of later formations. These widen the Island and prolong the ridge topography to Tottenville at the southern end. The hills attain a greater elevation than is found elsewhere along the shores of the Atlantic from Maine to Florida (the highest being Todt Hill at Ocean Terrace, 413 feet).

Geology

The "backbone" of Staten Island is composed of a massive body of serpentine rock of great but uncertain age. This material outcrops naturally in various places, including the tops of the highest hills, and has recently been exposed by excavations elsewhere. The character of the serpentine at the surface varies greatly from place to place. Being chemically unstable and liable to rapid weathering, especially by acids, it breaks down to a variety of materials, depending on the chemistry and exposure of the rock. (This process has been greatly facilitated by sulphur oxides and sulphuric acid in the air and rain water due to pollution.) The decay products include fibrous serpentine (chrysolite, "asbestos"), talc, and miscellaneous complex



Fig. 1. Maps of Staten Island showing historical (a) and surficial (b) geology.

carbonates. Associated with the serpentine in some locations are substantial amounts of limonite (bog iron ore), either in place at the surface of weathered serpentine or in the form of botryoidal masses, concretions ("puddingstone"), or massive nuggets frequently studded with quartz crystals.

Northwest of the serpentine-limonite mass, from Port Richmond to the Fresh Kills, is an area of low Triassic red shales of the Newark series, continuous across the Arthur Kill. Intruded through this is the most southerly outcrop of the Palisades diabase sill, with a large exposure in Mariner's Harbor ("Graniteville") and a smaller one at Travis. The diabase takes the form of a long, low hill trending northeast-southwest, roughly parallel to the serpentine ridge.

The southernmost third of the Island, south of the serpentine and east of the escarpment, is composed of plastic clays, sands and gravels of Cretaceous age, covering some 28½ square miles. Interstratified with them are local beds of poorly consolidated limonitic conglomerates.

The bedrock of the entire New York metropolitan region, the Manhattan formation of highly metamorphosed schists and granite pegmatites, does not outcrop anywhere on Staten Island although borings show that it underlies the Triassic and Cretaceous formations. The depth of the serpentine and the nature of its contact with the schist are poorly known.

All of the older formations on Staten Island are more or less concealed by Pleistocene and post-Pleistocene deposits. The Wisconsin glacier extended south to the serpentine escarpment, forming a terminal moraine covering the northeast corner of the Island and thence southwestward roughly along the escarpment, reaching Raritan Bay at Seguin Point. The thickness of the moraine is very variable, but it covers the serpentine to a greater or lesser degree, with only a small pocket at Dongan Hills unglaciated. North and west of the terminal moraine, the underlying formations are concealed by more or less unstratified drift, including a substantial number of erratics. Deep yellow and gray sands occur on the west shore at Arlington, Chelsea, Bloomfield, and Woodrow. These are partly of glacial origin and partly dune sands; they and the organic peat of the Fresh Kills marshes completely obscure the Cretaceous clays on the west shore except where excavations or erosion have exposed them locally. Southeast of the terminal moraine, the Cretaceous clays are buried under a thin outwash plain of sand and fine gravel.

Present Vegetation

As of 1971, between 1/3 and 1/2 of the land area of Staten Island could be classified as "developed," and the remaining area has all been strongly modified by man. The natural vegetation resulting from man's activities depends largely on the surficial geology as discussed above. All of the Island has been logged, cleared, or burned repeatedly since the earliest European settlement in the mid 17th century, and no "virgin forest" has existed for over a century. The oldest significant tracts of woodland are 60-80 years old. Such agriculture as existed on the Island expired within the last 30 years, leaving old fields to their successional fate. Old residential communities on the west shore have been nearly obliterated by brush since they were abandoned.

Staten Island lies within an area of oak-hickory climatic climax (Shelford, 1963) and the oldest woods on the Island are approaching this condition. The character of the climax vegetation varies, depending on soils. The peculiar chemistry of serpentine results in generally stunted vegetation of low species diversity, with a high percentage of edaphic endemism. The presence of moraine overlying the Staten Island serpentine has improved the soils so that the serpentine-barrens formation is much less well developed than on the unglaciated serpentines of southeastern Pennsylvania. The earlier Staten Island botanists found many of the serpentine endemics, such as *Clematis ochroleuca*, on the poorest soils (especially on Todt Hill). Increased fire frequency with the coming of civilization has probably led to their disappearance. Today, the serpentine soils support a fire disclimax dominated by little bluestem, *Andropogon scoparius*, often to the exclusion of nearly all other plants (fig. 2); switchgrass, *Panicum virgatum*, replaces it in wet areas. There are scattered clumps of sprouting black cherry (*Prunus serotina*) and gray birch (*Betula populifolia*) and of bayberry (*Myrica cerifera*) and winged sumac (*Rhus copallina*). Associated herbs include silverrod (*Solidago bicolor*), gray goldenrod (*S. nemoralis*), and white thoroughwort (*Eupatorium album*); lichens (*Cladonia* spp.) and mosses, especially silver moss (*Bryum argenteum*) are common and in many places are the only plants found with little bluestem.

Where fire has been excluded and a mature forest has developed (especially on heavy moraine, as on parts of Todt and Emerson Hills), the dominant species are red, black, white and

chestnut oaks (*Quercus rubra*, *velutina*, *alba*, and *prinus*), with an understory of maple-leaf viburnum (*Viburnum acerifolium*), lowbush blueberries (*Vaccinium* spp.), aster (*Aster cordifolius*), haircap moss (*Polytrichum commune*), etc. This is the only upland forest on Staten Island; although on serpentine it is actually somewhat richer than the second growth on granite and diabase overlooking the Hudson Valley farther north. The understory of most of the upland forest has been damaged by use for camping, scout training, etc. but is recovering in protected areas.

The lowland forests, particularly well developed in Mariner's Harbor and Willowbrook in the north and Annadale-Huguenot in the south, are on sandy soils but have a thick peaty surficial layer of poorly decomposed leaf litter. The dominants are pin, swamp white, and basket oaks (*Quercus palustris*, *bicolor*, *michauxii*), sweet gum (*Liquidambar styraciflua*) and black gum (*Nyssa sylvatica*). The shrub layer generally includes spicebush (*Lindera benzoin*), arrowwood (*Viburnum dentatum*), and highbush blueberries, while the understory has extensive areas of cinnamon and royal ferns (*Osmunda cinnamomea*, *O. regalis*), sensitive and dotted chain ferns (*Onoclea sensibilis*, *Woodwardia areolata*), and such spring wildflowers as Canada mayflower (*Maianthemum canadense*), troutlily (*Erythronium americanus*), and skunk cabbage (*Symplocarpus foetidus*).

The sands of the west shore are highly acid and formerly supported a Pine Barrens vegetation. This area has been subject to very frequent burning and many of the Pine Barrens endemics, like those of the serpentine, have been lost. Only a few—less than two dozen—native pitch and Virginia pines (*Pinus rigida*, *P. virginiana*) remain. The dry upland sands support a nearly impenetrable scrub overgrown with greenbrier (*Smilax* spp.). The main woody species are blackjack, scrub, and post oaks (*Quercus marilandica*, *ilicifolia*, *stellata*), gray birch, highbush and lowbush blueberries, sheep laurel (*Kalmia angustifolia*), and sweet pepperbush (*Clethra alnifolia*); in wetter spots chokeberry (*Aronia melanocarpa*) is very abundant (Figs. 3, 6). Some common herbaceous associates are fragrant goldenrod (*Solidago odora*), false indigo (*Baptisia tinctoria*), broomsedge (*Andropogon virginicus*), and on wet sites, bunchtop bluestem (*Andropogon glomeratus*) and switchgrass.

Sphagnum bogs were formerly numerous and well-developed



Fig. 2. Serpentine-limonite barrens, Fox Hills. Little bluestem disclimax. *Hesperia metea*, *Atrytonopsis hianna*, *Atrytone arogos*.

Fig. 3. Acid-sand barrens, Woodrow. Blueberry, catbrier, blackjack, and scrub oaks. Oak-feeding *Erynnis* and *Satyrium*.

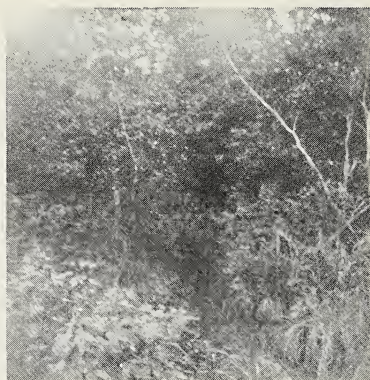
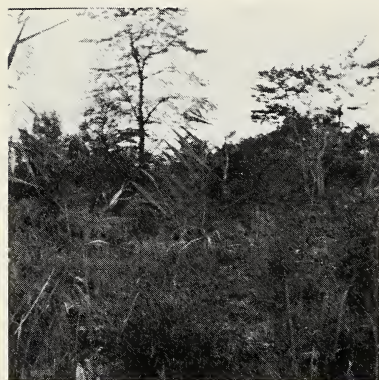


Fig. 4. Sphagnum bog, Bloomfield. Habitat of *Euphyes dion*, *E. bimacula*, *E. conspicua*, *Lethe eurydice*, *Poanes viator*, *P. massasoit*.

Fig. 5. Tussock sedge in boggy stream, Bloomfield, *Lethe appalachia*, *Poanes massasoit*, *Euphydryas phaeton*.

in the sandy areas, but are now restricted to a few sites in Chelsea, Woodrow, and Bloomfield and have lost many of their distinctive plants. Aside from the peat mosses, characteristic species today include various sedges (*Carex*, *Cyperus*, several species), bur-reed (*Sparganium eurycarpum*), buttonbush (*Cephalanthus occidentalis*), poison sumac (*Rhus vernix*), and bunchtop bluestem (Fig. 4). The bogs are usually ringed by a red maple (*Acer rubrum*) zone forming a transition to the lowland oak forest (Fig. 5, 7).

The Tottenville area includes sand scrub, much of it burned in a particularly hot wildfire in 1962 and now supporting very dense populations of sassafras (*Sassafras albidum*) seedlings. One pine barrens-blackjack oak area still exists along Hylan Blvd. The southernmost tip of the Island, at Ward's Point, has a richer soil supporting thickets of hackberry (*Celtis occidentalis*), as well as some local herbs, including yellow giant hyssop (*Agastache nepetoides*) and feverwort (*Triosteum perfoliatum*).

The unglaciated coastal plain along the south shore is all highly disturbed and is mostly covered by an array of sandy-(circumneutral)-soil weeds such as white sweetclover (*Melilotus alba*), goat's beard (*Tragopogon pratensis*), camphorweed (*Heterotheca subaxillaris*), seaside goldenrod (*Solidago sempervirens*) and other goldenrods, narrow-leaved thoroughwort (*Eupatorium hyssopifolium*), and many beach grasses (e.g., triple awn, *Aristida tuberculosa*). The salt marshes behind the beaches have been filled and are dominated by tall reed (*Phragmites communis*); near the bungalows are thickets of cottonwood (*Populus deltoides*), black cherry, willow, and winged sumac.

The Fresh Kills salt marshes on the west shore support the usual coastal vegetation, with cordgrass (*Spartina* spp.) covering large areas; behind the cordgrass are meadows of marsh spikegrass (*Distichlis spicata*) with associated herbs (orach, *Atriplex hastata*; water hemp, *Acnida cannabina*; salt-marsh fleabane, *Pluchea purpurascens*) and subshrubs (*Iva axillaris* and *Baccharis halimifolia*) (Fig. 8). More than half the salt marsh area has been obliterated by sanitary landfill, which unlike the hydraulic landfill on the south shore has a large flora of annual weeds. Some of these, which may form large stands, are rare or absent elsewhere on the Island (e.g., *Kochia scoparia*, *Chenopodiaceae*).

The long-urbanized north shore has many vacant lots occu-



Fig. 6. Scrub and young oak-black gum forest on wet acid sand, Mariner's Harbor. *Hesperia metea*, *Satyrrium liparops*, *Erynnis icelus*.

Fig. 7. Buttonbush-sedge bog, Woodrow. *Euphydryas phaeton*, *Poanes massasoit*, *Satyrrium falacer* and *caryaevorus*.



Fig. 8. Salt meadows, Bloomfield. Pin oak forest in background. Habitat of *Panoquina panoquin* and *Poanes viator*.

pied by adventive weeds such as annual and perennial wormwoods (*Artemisia annua*, *A. vulgaris*), peppergrass (*Lepidium virginicum*), common and giant ragweeds (*Ambrosia artemisiifolia* and *A. trifida*), horseweed (*Leptalon canadense*), dump-heap sunflower and Jerusalem artichoke (*Helianthus annuus* and *tuberosus*), white sweetclover, Mexican tea and lamb's quarters (*Chenopodium ambrosioides* and *C. album*), giant and green foxtails (*Setaria faberii* and *S. viridis*), etc. The succession on vacant lots results in glades of tree-of-heaven (*Ailanthus altissima*) with an understory of Japanese honeysuckle (*Lonicera japonica*) and Japanese knotweed (*Polygonum cuspidatum*). In some locations, especially on serpentine, red and paper mulberries (*Morus rubra*, *Broussonetia papyrifera*) and smooth aster (*A. laevis*) may be prominent.

Permanently disturbed commercial waterfront areas in Stapleton, Saint George, and Port Ivory-Howland Hook have a diverse weedy vegetation including ballast relicts not found elsewhere on the Island. Examples are Jerusalem oak (*Chenopodium botrys*), catnip (*Nepeta cataria*), and nodding thistle (*Carduus nutans*).

The Butterfly Fauna

Except for the marked acid soil-Pine Barrens element, Staten Island's butterfly fauna closely resembles that of the Tinicum-Eastwick area in southwest Philadelphia (Shapiro, 1970a). There are 73 species recorded from Tinicum and 106 from Richmond County (92 recently); the two lists have 69 species in common. The list of shared species includes all of the widespread, common colonizing species and most of the migrants. Although the potential climax vegetation of the two areas is similar, Tinicum is more recently and uniformly disturbed. The vegetation of non-marsh habitats at Tinicum is similar to that of similarly de-developed areas on Staten Island, and this accounts for the very close faunal similarities. The four species found at Tinicum but not on Staten Island are *Urbanus proteus*, *Thorybes confusus*, and *Erynnis zarucco*—all at the northern extremities of their ranges at Philadelphia; and *Asterocampa clyton* which is replaced on Staten Island by *A. celtis* (not found at Tinicum, although the two species are extensively sympatric and at least in the south often occur together).

The species found on Staten Island but not at Tinicum are a heterogeneous lot. Northern species not penetrating the coastal plain south to Tinicum are *Nymphalis j-album*, *N. milberti*,

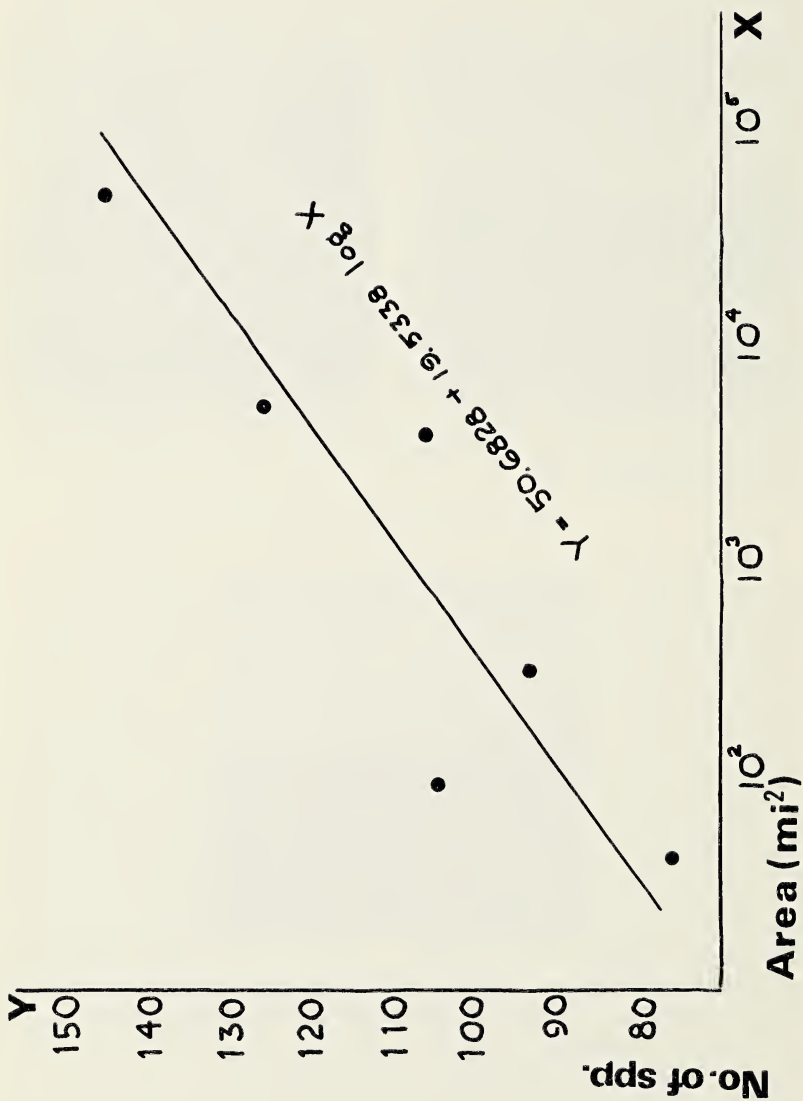


Fig. 9. Regression of species number on log area for well-studied north-eastern U.S. butterfly faunas.

Lethe anthedon, *Speyeria aphrodite*, *Boloria toddii*, *Polygonia progne*, *Satyrrium acadica*, *Erynnis martialis*, *Polites mystic*, and *Pieris "napi"* (probably *P. virginienensis*). All of these except the last have been taken on the upland piedmont within 35 miles of Philadelphia—most of them actually within the city limits.

The Staten Island fauna has been compared in detail with those of five other areas in the northeast which have been intensively collected by single individuals using uniform methods over the entire season. The relationship of area to species number was determined for these six areas by means of regression; species number is a linear function of log area (Figure 9). The data used are given in Table 1.

The predicted species number for Staten Island based on area alone is 86.73. The observed value of 104 (106) actually exceeds the estimate plus the standard error of estimate and is the largest percentage deviation from predicted values of the six localities. This very high number probably reflects the Island's seaboard location; of the 104 species considered, at least 14 can be considered irregular immigrants from the south, and at this latitude these are confined to the immediate coastal strip. Some of the overall unexplained variance is probably due to latitude alone; this applies in particular to the low figure for central New York. The low numbers for Tinicum and the District of Columbia both probably reflect the loss of special habitats and their associated species.

The composition by family of the faunas (Table 2) also sheds light on their differences. The families with wide-ranging, ecologically tolerant species (Papilionidae, Pieridae, part of Nymphalidae) show little increase in species number with area. The two families with many highly specialized species—Lycaenidae and Hesperidae—show a steady increase in species number with area. (The Virginia value for Lycaenidae is certainly an underestimate, possibly by 5-10 species.) The most striking difference between the Tinicum and Staten Island lists is the lack of Lycaenidae in the former.

Most of the missing Lycaenid species are associated with acid-soil vegetation, as are some of the missing Hesperids: *Satyrrium edwardsii*, *S. liparops*, *Incisalia irus*, *I. augustinus*, *I. niphon*, *Erynnis icelus*, *E. brizo*, *E. baptisiae*, *Hesperia leonardus*. Species associated with serpentine vegetation, which does not occur at Tinicum, include *Hesperia sassacus*, *Atrytonopsis hianna*, *Atrytone arogos*, and perhaps *Hesperia attalus*. The lack of sphagnum bogs and sedgy areas at Tinicum—these pre-

Table 1. Data for regression analysis of species-area relationship in northeastern U.S. butterfly faunas.

Locality	No. of Spp. Y	Area (sq.mi.)	Log Area X	Reference	Calculated No. of Spp. Y _x
Tinicum- Eastwick ^a	73	40	1.6021	Shapiro, 1970	82
Staten Island	104 ^b	70	1.8451	Present paper	87
District of Columbia	92 ^c	250 ^d	2.3979	Clark, 1932	98
Central New York ^e	105 ^f	3669	3.5646	Shapiro, unpublished	120
Delaware Valley, Pa. - N.J.	128	3846	3.5850	Shapiro, 1966	121
Virginia	146 ^g	40815	4.6108	Clark and Clark, 1951	141

Regression of Y on X: $Y_x = 50.6828 + 19.5338 X$

Standard error or estimate: 13.4604

Percentage of variance accounted for by regression: 78.37%

Notes: ^aPhiladelphia and Delaware Counties, Pennsylvania

^bPieris undetermined species and Papilio palamedes excluded.

^cUnderestimate, probably by at least 5 species.

^dApproximation from the rough boundaries indicated by Clark, 1932.

^eTompkins, Schuyler, Cortland, Tioga, Chemung and Steuben Counties.

^fPhoebis philea excluded

^gUnderestimate, probably by 10 species

viously occurred but were drained and/or filled before 1920—excludes the three sedge-feeding *Euphyes* and *Poanes massasoit*, all of which still occur near Philadelphia. Seemingly suitable habitats exist at Tinicum for *Harknclenus titus*, *Satyrium caryaevorus*, and *Feniseca tarquinius*, and any of these could still turn up there. The European Skipper, *Thymelicus lineola*, colonized Staten Island about 1968-69 (Shapiro, 1971) and is also likely to have entered Tinicum since the survey of that area was completed in 1966; it has been reported from Bucks, Montgomery, Delaware, and Chester Counties, Pennsylvania. *Mitoura gryneus*—like its host plant, red cedar—is found at neither locality today. Finally, there are three southern strays reported from Staten Island but not from Tinicum. Two of these, *Pan-thiades m-album* and *Graphium marcellus*, occur frequently around Philadelphia. The third, *Papilio palamedes*, was taken so far out of range that it must be considered an extremely rare instance of long-distance dispersal.

Like Tinicum, Staten Island is on the Atlantic migratory flyway and receives substantial numbers of immigrant butterflies from the south. Being farther north than Tinicum, it receives them more sporadically; breeding, when it occurs, begins later in the season and overwintering is less frequent. Winter survival of southern species requires not only shelter from cold, desiccating winds but proper timing of the life cycle so that the most resistant stages are available to survive the winter. This is an exceptional circumstance in a climate as irregular as that of Staten Island. Being directly on the coast, the Island is a feeding and assembly area for great numbers of monarchs and, at times, of painted ladies and other mass migrants (Shapiro, 1970b). There is reason to believe that migrant monarchs from southern Ontario, upstate New York, and all of New England converge on Staten Island. The great amounts of flowering goldenrod and aster on the south shore are an important food source for the migratory swarms. Their welfare may be jeopardized if the coastal strip is developed and this food source is no longer available.

On the whole, Staten Island has fared extraordinarily well to date insofar as retention of its butterfly fauna is concerned. Only two resident species—*Incisalia niphon* and *Mitoura gryneus*—have definitely disappeared in the past century, both with the eradication of their host plants. A third, some sort of *Pieris*, was probably gone well before then. *Incisalia augustinus*, *Hesperia sassacus*, *Erynnis brizo* and *Thorybes bathyllus* are not

known definitely from the Island at this time but any or all may still be present. The other missing species—*Nymphalis j-album*, *N. milberti*, *P. s. eubule*, *C. caesonia*, *G. marcellus*, *P. cressphontes*, *P. communis*—are all probably immigrants, some of which have bred at times in the past and may do so again. Staten Island has gained two resident species—*Colias eurytheme* and *Thymelicus lineola*—and populations of another, *Poanes viator*, have increased greatly due to man's activities.

Despite changes in the extent and character of forests and serpentine barrens on the Island, the butterflies of these habitats have not suffered appreciably because the plant species on which they depend have not suffered. Staten Island forests probably never were very rich in butterflies; the persistence of such species as *Lethe anthedon* and *L. appalachia* is mildly surprising.

Many of the species which Davis regarded as widespread, common Island residents have undergone great reductions of population size and restriction of ranges. A number of these are obviously endangered; known today from only one or two localities, they could be eliminated from the Island by a few hours' work with a bulldozer. Most or all of them, moreover, will be. They are located on the west shore in the acid barrens area recently zoned as an industrial park, or in the oak scrub scheduled to become the "new city" of South Richmond in Huguenot and Pleasant Plains. Even if the Staten Island "green belt" can be protected against its numerous enemies, it contains upland oak forests and serpentine barrens but no acid scrub suitable for these species. Butterflies likely to become extinct on Staten Island within five years are *Lethe appalachia*, *L. eurydice*, *Speyeria idalia*, *S. aphrodite*, *Boloria selene*, *B. toddii*, *Euphydryas phaeton*, *Chlosyne nycteis*, *Polygonia progne*, *Satyrium acadica*, *S. liparops*, *S. edwardsii*, *Incisalia irus*, *Hesperia leonardus*, *Polites mystic*, *Poanes massasoit*, *Atrytone arogos*, *A. logan*, *Euphyes dion*, *E. conspicua*, and *E. bimacula*, a total of 21 species, or one-fifth of the recorded fauna.

Several normally common butterfly species—*Cercyonis alope*, *Speyeria cybele*, *Limenitis astyanax*, *L. archippus*, *Polygonia comma*, *Euphyes ruricola*—were at alarmingly low levels in 1971. Their scarcity could be due to intrinsic cyclicality, aerial spraying for mosquitoes, air pollution, or a multitude of other factors. As widespread, successful species in the northeast, however, they presumably have high enough rates of dispersal and increase to rebound from their present lows when conditions

are once again suitable for them. The specialized, acid-barrens and bog species have nothing in their favor but delays in bulldozing. For them, densities are approaching irreversible lows, or the extent of suitable habitat is nearing the point of no return.

The future of the Island fauna can be seen in the vacant lots on the decaying north shore. The butterflies of vacant lots in Saint George or Stapleton are the same as those in Queens, Newark, or Philadelphia: *Phyciodes tharos*, *Strymon melinus*, *Everes comyntas*, *Pieris rapae*, *P. protodice*, *Colias eurytheme*, and *Pholisora catullus*. (The checkered skipper, *Pyrgus communis*, joins the association from Philadelphia southward.) All of these species are vagile colonizers with high reproductive rates, feeding on weeds and obviously tolerant of air pollution. They and *Poanes viator*, which swarms on undeveloped hydrofills, have increased in numbers and range as the native and specialized forms have declined. Some of the common upland and serpentine species will persist in the green belt, just as they have in the Terminal Moraine Natural Area System in Queens; so *Satyrium falacer*, *S. caryaevorus*, *Nymphalis antiopa*, *Euptychia cymela*, *Speyeria cybele*, *Poanes zabulon*, *P. hobomok*, and *Erynnis juvenalis* will remain in the Island fauna. So will the strongly migratory *Precis coenia*, *Danaus plexippus*, and three *Vanessa* spp. This leaves us a fauna of some 21 species to look forward to by the year 2000, a fauna virtually identical to that of the borough of Queens today. If there are more discoveries to be made in the Staten Island butterfly fauna, they had better be made soon.

Annotated List of Species

SATYRIDAE

1. *Lethe anthedon* A. H. Clark. Northern Pearly-Eye

Apparently rare. Two single records in the serpentine highlands in densely wooded country. Univoltine everywhere in the north. Population levels of this species tend to fluctuate both locally and from season to season; it may be found commonly some years in places where it is usually rare, and this may be true on Staten Island.

HOST PLANTS: Not recorded on Staten Island. Presumably a grass, perhaps a *Muhlenbergia*? (*Brachyelytrum* and *Uniola*, both recorded hosts, do not occur here.)

RECORDS: Brielle Ave. near Buck's Hollow, vii.21.71; Rockland Ave. near Sea View Hospital, vii.16.71.

2. *Lethe appalachia* R. L. Chermock. Southern Eyed Brown

Local but frequent in sedgy areas near streams through brushy country, on Staten Island mainly on the acid lowlands. The butterflies remain in shady situations, not visiting flowers; apparently associated with tussock sedge (*Carex stricta*) in Bloomfield. One brood, July.

HOST PLANTS: *Carex stricta*? Perhaps other *Carex*.

RECORDS: Willowbrook, vii.21.71; South Avenue, Bloomfield, vii.22.71, vii.27.71.

3. *Lethe eurydice* Johansson. Northern Eyed Brown

Sedgy marshes and acid bogs with abundant sunshine, very local but frequent where it occurs. Unlike the southern eyed brown, this species visits blossoms of swamp milkweed (*Asclepias incarnata*) and Joe-Pye weed (*Eupatorium* spp.) rather freely. One brood, mainly in July ("June to September," Davis). Represented in the U.S. National Museum by two Island specimens with incomplete data. Not seen in the same localities as *L. appalachia* on the Island.

HOST PLANTS: Not recorded here; probably *Carex*, perhaps *C. stricta*.

RECORDS: Mariner's Harbor (Arlington), vii.15.71, vii.31.71; South Avenue bogs, vii.22.71, vii.27.71, viii.16.71; Midland Beach, viii.15.71. Recorded by Richard Pine from near Susan Wagner High School, Sea View, vii.20.71.

4. *Euptychia cymela* Cramer. Little Wood Satyr

Common and widespread throughout in brushy meadows and open woods, regardless of soils; common in mulberry thickets on serpentine, Stapleton. One brood, June to late July ("last days of May . . . to first days of August," Davis). This species frequents hedgerows and dense vegetation, and is difficult to capture unless it can be kept in the open.

HOST PLANTS: Orchard grass (*Dactylis glomerata*) (ova, Stapleton).

RECORDS: Stapleton, vii.1.71; Mariner's Harbor, vii.1.71; South Avenue, Bloomfield and Chelsea, vii.2.71, vii.12.71, vii.27.71; Pleasant Plains, vii.3.71; Totenville, vii.3.71, vii.14.71; Todt Hill, vii.4.71; Buck's Hollow, vii.4.71; Travis, vii.6.71; Sea View, vii.16.71; Midland Beach, vii.20.71; Willowbrook, vii.21.71. (vii.1-vii.27)

5. *Cercyonis alope* Fabricius. Common Wood Nymph

Frequent and widespread in brush land, including the acid west shore. Common in hedgerows on the grounds of Willowbrook State School, straying into adjacent meadows. Absent from extensive bluestem (serpentine) areas. "June to September inclusive" (Davis). July-mid August, 1971; one brood. Not very variable on Staten Island, our population perhaps best

called *maritima* Edwards (FW blotch deep rusty orange, slightly clouded with brown in some specimens). When alarmed, the butterflies dodge into cover. A pair taken *in copula* at Willowbrook, vii.21.71, 11.50 a.m.

HOST PLANTS: Grease grass, purple top (*Tridens flavus*) (ova, larvae, Willowbrook); perhaps other grasses.

RECORDS: South Avenue, Mariner's Harbor, vii.2.71; South Avenue, Bloomfield, vii.12.71, vii.27.71, vii.16.71; Tottenville, vii.14.71, vii.28.71; Willowbrook, vii.21.71; Wolfe's Pond Park, vii.2.71. (vii.2-viii.16).

DANAIDAE

6. *Danaus plexippus* Linnaeus. Monarch (Fig. 11c)

Abundant everywhere in open country after midsummer, continuously brooded, probably two to four broods, depending on the timing of the spring immigrants. "May to November inclusive," Davis, includes a record of xi.25.94. Staten Island is on the main migratory flyway. Davis records migrations on ix.29.89 and ix.8.99 (the latter seems very early). On x.7.70 some 50,000 were seen on the beach at Great Kills Park. The 1971 peak came on ix.24, with 20-25,000. On the 1970 date a specimen tagged at Cobourg, Ontario was collected (locality confirmed by Dr. F. Urquhart, University of Toronto).

Migrants accumulate on the south shore during spells of settled, warm, dry weather, feeding on the abundant asters and goldenrods. Predation by the Chinese mantis (*Paratenodera sinensis*) is heavy at this time. The huge flocks depart ahead of stormy weather, apparently with the onset of a sustained strong wind, but stragglers continue to appear for weeks and secondary buildups may occur. Although monarchs are normally sexually inactive while migrating, a pair *in copula* was observed at South Beach on x.28.71 at 3 pm. with the temperature in the mid 60's.

Many abnormal monarchs have turned up in the migratory swarms. Some fifteen with depigmentized blotches on the wings (similar to those produced by microcauterization of the pupal prismatic maculae, Urquhart and Tang 1971) have been taken. On September 6, 1970 in the early part of the migration, a female with all the subapical spots white was taken at Willowbrook. This individual (Fig. 10f) closely resembles the tropical American subspecies *megailippe* Hubner. There is at least one prior record of this "form" in New York (Clark and Clark, 1951).

HOST PLANTS: Milkweeds: *Asclepias syriaca* (ova, larvae, Mariner's Harbor, Saint George, Tottenville), *A. incarnata* (Woodrow, Tottenville). Probably other *Asclepias*.

RECORDS: Fox Hills, vii.31.70, ix.11.70, ix.16.71, x.12.71; Willowbrook, ix.6.70, x.16.71; Richmondtown, ix.13.70, x.13.71; New Springville, ix.20.70; Great Kills, ix.26.70, x.7.70, ix.24.71; Tottenville, x.5.70, vii.18.71, ix.22.71, x.6.71; Port Richmond, x.20.70, x.23.70, xi.1.70, xi.3.70, xi.9.70, ix.3.71, xi.2.71; Wolfe's Pond Park, x.24.70; Graniteville, x.28.70; Old Place, xi.7.70; Mariner's Harbor, vii.1.71, viii.14.71, x.27.71; South Avenue, Bloomfield, vii.2.71, ix.1.71; Port Ivory, vii.15.71; Sea View, vii.16.71, x.30.71; Midland Beach, vii.20.71, ix.8.71, ix.15.71, x.4.71, x.19.71, x.26.71, x.29.71, xi.4.71, xi.6.71; Annadale, ix.25.71; Travis, ix.29.71; Oakwood, x.5.71, x.28.71, xi.18.71; New Dorp, x.21.71. (vii.1-xi.18)

HELICONIIDAE

7. *Agraulis vanillae* Linnaeus. Gulf Fritillary

A rare migrant from much further south, recorded once. The normal food plants, *Passiflora* spp., do not occur here.

RECORDS: Port Richmond, xi.1.70.

NYMPHALIDAE

8. *Euptoieta claudia* Cramer. Variegated Fritillary

A scarce but perhaps consistent immigrant. "Less than a dozen specimens have been seen and these usually in late summer and fall. The earliest record is July 11, at Richmond Valley. Two specimens observed . . . at Dongan Hills on September 18, 1910" (Davis). Weedy roadsides and dry fields, visiting flowers freely. The males are very strong fliers and appear to "fly a beat." Not known to breed on Staten Island, but food plants (*Viola*) are available. Multiple brooded in the south, breeding and overwintering some years as far north as Philadelphia.

RECORDS: Great Kills, ix.23.70; Graniteville, x.28.70; Fox Hills, ix.16.71; Travis, ix.29.71; Midland Beach, xi.6.71.

9. *Speyeria idalia* Drury. Regal Fritillary

Apparently rare today; a species noted for its fluctuations in abundance. "Last days of June through July, August and September" (Davis). Generally a resident of wet meadows, especially upland, with violets and abundant wildflowers; the single Staten Island capture was made on a roadside Black-eyed Susan (*Rudbeckia hirta*) in brush land near Clermont Avenue and Aspinwall Street.

RECORDS: Tottenville, vii.5.71.

10. *Speyeria cybele* Fabricius. Great Spangled Fritillary

Formerly common ("June, July, August, and September. The males appear in numbers in June a day or so before the females," Davis) but now unaccountably rare, perhaps at an abnormal (and transient) low level in 1971. Open country generally, visiting milkweed blossoms. One brood a year.

HOST PLANTS: Presumably violets, as elsewhere.

RECORDS: South Avenue, Chelsea, vii.12.71, viii.16.71; Tottenville, vii.14.71; Sea View, vii.16.71.

11. *Speyeria aphrodite* Fabricius. Aphrodite Fritillary

Local, but frequent, on acid-soil areas on the west shore and at Tottenville; not seen elsewhere. Most often noted on milkweeds by the roadside in scrubby country. Numbers of this species may have increased since Davis' time, since he wrote: "A single specimen taken on June 29. One seen at close range in the Clove Valley . . . August 2, 1908." In upstate New York generally found upslope of *S. cybele* and on poorer soils, but not extending on the acid sand into the New Jersey pine barrens. Staten Island may represent its southernmost record on the Atlantic coastal plain.

HOST PLANTS: Oviposits on and near *Viola lanceolata*, *V. primulifolia*, and *V. fimbriatula* (west shore).

RECORDS: Univoltine. Tottenville, vii.14.71; South Avenue, Mariner's Harbor to Travis, vii.22.71, vii.27.71, viii.16.71.

12. *Boloria selene myrina* Cramer. Silver-bordered fritillary

"May to September inclusive" (Davis). Very local, two colonies known but frequent at each; two or three broods. Suitable habitats for this species—wet, sedgy meadows—have decreased in extent since Davis' time. At Midland Beach it occurs along the edge of a reed marsh and strays into adjacent brush.

HOST PLANTS: Unknown, but perhaps not violets on the Island; a suspected willow feeder in parts of upstate New York.

RECORDS: Tottenville, vii.5.71, ix.22.71; Midland Beach, vii.20.71.

13. *Boloria toddii* Holland. Meadow Fritillary

Apparently greatly decreased in numbers since Davis' time, but the Meadow Fritillary is well-known for its eruptive tendencies and may again become common in suitable habitats, grassy wet meadows. "June, July and August . . . formerly found in the Clove Valley . . . a single specimen in Buck's Hollow, August 7, 1910."

HOST PLANTS: Probably violets, as elsewhere.

RECORDS: Tottenville, vii.14.71, x.6.71; Pleasant Plains, v.10.71, vii.3.71; three broods?

14. *Euphydryas phaeton* Drury. Baltimore

Rare and local today, by boggy ditches and swales on the west shore. One brood (July, 1971: "May and June, sometimes in considerable numbers" (Davis); often in June on the New Jersey Piedmont). A colony of wintering larvae observed on the food plant on Woodrow Road near Winant Avenue, Woodrow, September 25, 1971.

HOST PLANT: Turtlehead (*Chelone glabra*), still a fairly frequent marsh and bog plant on the Island.

RECORDS: South Avenue, Bloomfield, vii.12.71, vii.22.71.

15. *Chlosyne nycteis* Doubleday. Silver Crescent

Rare, in acid scrub. Unreported for the Island by Davis. Probably at least partially double-brooded as it is in Westchester County. The largest female I have ever seen was taken July 3, 1971 on a brush trail in Huguenot.

HOST PLANTS: Perhaps *Helianthus* species.

RECORDS: Huguenot, vii.3.71; Tottenville, ix.6.71.

16. *Phyciodes tharos* Drury. Pearl Crescent

Abundant everywhere in open country, including vacant lots. Continuously brooded, three to four broods, the larvae overwintering. Late April-mid November ("early May to October inclusive," Davis). Comstock (1940) records this species from "Staten Island, March 29." The record (Davis, 1910) is actually of a larva found iii.29.03.

Spring and autumn specimens, especially females, are heavily marked beneath (form *marcia*): a few April and May specimens extremely so.

HOST PLANTS: *Aster pilosus*, *ericoides*, and *laevis* (numerous stations; ova and larvae).

RECORDS: Fox Hills, vii.31.70, ix.11.70, v.24.71, ix.16.71, x.12.71; Willowbrook, ix.6.70, vii.21.71, x.16.71; Port Richmond, x.20.70, ix.4.71, ix.12.71; Graniteville, x.28.70; Mariner's Harbor, iv.21.71, x.1.71, x.27.71; Pleasant Plains, v.10.71, vii.3.71; South Avenue, Arlington to Travis, v.12.71, v.27.71, vii.2.71, vii.12.71; Todt Hill, v.18.71; Tottenville, v.25.71, vii.14.71, ix.6.71, ix.22.71, x.6.71; Huguenot, v.26.71; Stapleton, vii.1.71, ix.7.71; Sea View, vii.16.71, x.30.71; Midland Beach, vii.20.71, ix.8.71, ix.15.71, x.4.71, x.19.71, x.26.71, x.29.71, xi.6.71, xi.17.71; Annadale, ix.25.71; Travis, ix.29.71; Oakwood, x.5.71, x.28.71; South Beach, x.8.71; New Dorp, x.21.71. (iv.21-xi.17)

17. *Polygonia interrogationis* Fabricius. Question Mark

Common in mid- to late summer in highly disturbed, overgrown habitats, especially on the north and south shores. Not seen in spring and only twice in fall, these being the only records of the winter (light) form; perhaps, as in central New York, not always overwintering here. Several males of the summer (dark) form took up territorial positions on a stone wall at Swan and Homer Streets, Stapleton, about 90 minutes before sunset daily in late July. Eight larvae collected on the Island were all parasitized by a Tachinid, *Compsilura concinnata*.

On July 21, 1971 this species, *P. comma*, and *Vanessa atalanta*, were all common at flowing sap on an injured red maple near the Victory Blvd. entrance to Willowbrook Park, showing no inter- or intraspecific aggression while feeding.

HOST PLANTS: Japanese Hop (*Humulus japonicus*) (larvae, Stapleton, Port Richmond, Midland Beach).

RECORDS: Summer forms: Fox Hills, vii.31.70; Tottenville, vii.14.71; Midland Beach, vii.20.71; Willowbrook, vii.21.71; South Avenue, Bloomfield, vii.22.71; Stapleton, vii.22.71; Mariner's Harbor, vii.31.71. Winter forms: New Springville, ix.20.70; Stapleton, x.14.71. (vii.14-ix.20).

18. *Polygonia comma* Harris. Comma

Infrequent, in habitats similar to the last. Probably both widespread *Polygonias* have two generations yearly, but the data are scanty. "Less common than (the Question Mark)" (Davis).

HOST PLANTS: Unknown locally; presumably Ulmaceae or Urticaceae.

RECORDS: Buck's Hollow, x.1.70 (winter form); South Avenue, Chelsea, vii.2.71; Willowbrook, vii.21.71 (summer forms).

19. *Polygonia progne* Cramer. Gray Comma

Davis records a single specimen at Richmondtown, February 24, 1906. One modern record at Tottenville, a male sitting in the middle of Clermont Avenue. In upstate New York, an upland species of woods edges and brushy situations.

HOST PLANTS: Unknown on Staten Island.

RECORD: Tottenville, x.6.71.

20. *Nymphalis j-album* Boisduval and LeConte. Compton Tortoise

No modern records. "Hibernated individuals in early spring and fresh examples in midsummer. About one-half of the specimens taken on the Island have been found in dwellings, usually in the fall" (Davis). A northern species with notoriously unstable populations; occasional in the Pine Barrens and south to Philadelphia. Perhaps extinct in the entire New York metropolitan area.

21. *Nymphalis antiopa* Linnaeus. Mourning Cloak

"Sometimes seen as early as the latter part of February and as late as November." April-November, frequent, mostly in sunlit spots in woodlands (at all elevations), and occasional on milkweeds and other tall roadside flowers. One taken indoors in an apartment building November 6, 1970 circling a light bulb at 11:30 p.m. Probably one brood, perhaps with a partial second some years.

HOST PLANTS: Willows (*Salix nigra*) (larvae, Willowbrook); Cottonwood (*Populus deltoides*) (larvae, Midland Beach); preferring small or shrubby specimens.

RECORDS: Port Richmond, xi.6.70; South Avenue, Bloomfield and Mariner's Harbor, iv.11.71, vii.2.71, vii.12.71; Todt Hill, vii.4.71; Buck's Hollow, vii.4.71; Willowbrook, vii.21.71.

22. *Nymphalis milberti* Godart. Milbert's Tortoise Shell

Presumably extinct on Staten Island. "One specimen taken near Silver Lake . . . in October 1886. Seen at Clifton . . . October 13, 1902 and on September 25, 1910" (Davis). A northern species of disturbed, weedy sites near dwellings and on flood plains, ranging occasionally south to Philadelphia. Triple-brooded in central New York. The host plants, stinging nettles, are common on Staten Island.

23. *Vanessa atalanta* Linnaeus. Red Admiral

Frequent and widespread in open country, particularly in disturbed, weedy sites, and on stream banks near the host plant. Recorded by Davis, "March to November inclusive. One seen December 13, 1891." Partially double-brooded, the main flight in midsummer. The males are territorial in late afternoon and remain active into twilight. "Wet form" individuals are larger and blacker than "dry form" ones, often with the red band interrupted; the "wet form" commonest in midsummer.

HOST PLANTS: Nettle (*Urtica dioica*) (larvae abundant, Travis); Pellitory (*Parietaria pensylvanica*) (larvae, Mariner's Harbor).

RECORDS: Fox Hills, ix.11.70; Richmondtown, ix.13.70; New Springville, ix.20.70; Great Kills, x.7.70, ix.24.71; Mariner's Harbor, vii.1.71, vii.15.71; South Avenue, Chelsea, vii.2.71; South Avenue, Bloomfield, vii.12.71; Todt Hill, vii.4.71; Port Ivory, vii.15.71; Willowbrook, vii.21.71; Port Richmond, viii.17.71, ix.3.71; Travis, ix.29.71; Oakwood, x.28.71. Hibernators not observed in 1971. (vii.1-x.28)

24. *Vanessa cardui* Linnaeus. Painted Lady

"August, September, and October, but not common. Plentiful in September 1884. A single example near Richmond (town), April 24, 1897" (Davis). The occurrence of this species on Staten Island depends on the strength of its migration, as it does not normally overwinter in the northeast. Abundant in September-October 1970, especially on and near the south shore, and apparently migrating southward with the monarchs on October 7. Only one individual seen in 1971. Continuously brooded in good years, up to three generations when breeding begins in May or early June.

HOST PLANTS: Larval nests common on thistles (*Cirsium vulgare*, *C. discolor*) (Tottenville, Mariner's Harbor, Travis, Fox Hills) in 1970.

RECORDS: Fox Hills, ix.11.70; New Springville, ix.20.70; Great Kills, ix.26.70, x.7.70; Port Richmond, x.19.70; Wolfe's Pond Park, x.24.70; Tottenville, x.6.71.

25. *Vanessa virginiensis* Drury. Painted Beauty, American Painted Lady

Frequent generally in open country, including gardens and vacant lots, but common only on the south shore beaches with its food plant. At least two broods ("early spring to November inclusive," Davis). Observed migrating with *V. cardui*, *D. plexippus*, and a few *V. atalanta* at Great Kills, x.7.70.

On ix.11.70 some ten males of this species were "defending" territories on hilltops in Fox Hills about 45 minutes before sunset.

HOST PLANTS: Sweet Everlasting (*Gnaphalium obtusifolium*); larvae common at Great Kills and South Beach.

RECORDS: Fox Hills, vii.31.70, ix.11.70; Great Kills, ix.23.70, ix.26.70, x.7.70, ix.24.71; Port Richmond, x.24.70, xi.1.70, xi.8.70, i.9.70; Tottenville, v.25.71, vii.14.71, x.6.71; Port Ivory, vii.15.71; Willowbrook, vii.21.71; South Avenue, Chelsea, vii.22.71; Travis, ix.29.71; Oakwood, x.5.71; South Beach, x.8.71; Midland Beach, x.26.71, x.29.71, xi.17.71. (v.25-xi.17)

26. *Precis coenia* Hubner. Buckeye (Figs. 10a-c)

Common and general in low, open country especially on the beaches; less frequent on the north shore, and seemingly absent from the high hills. "June to November inclusive," continuously brooded and continuing to emerge until hard frost. The Buckeye probably does not overwinter at all

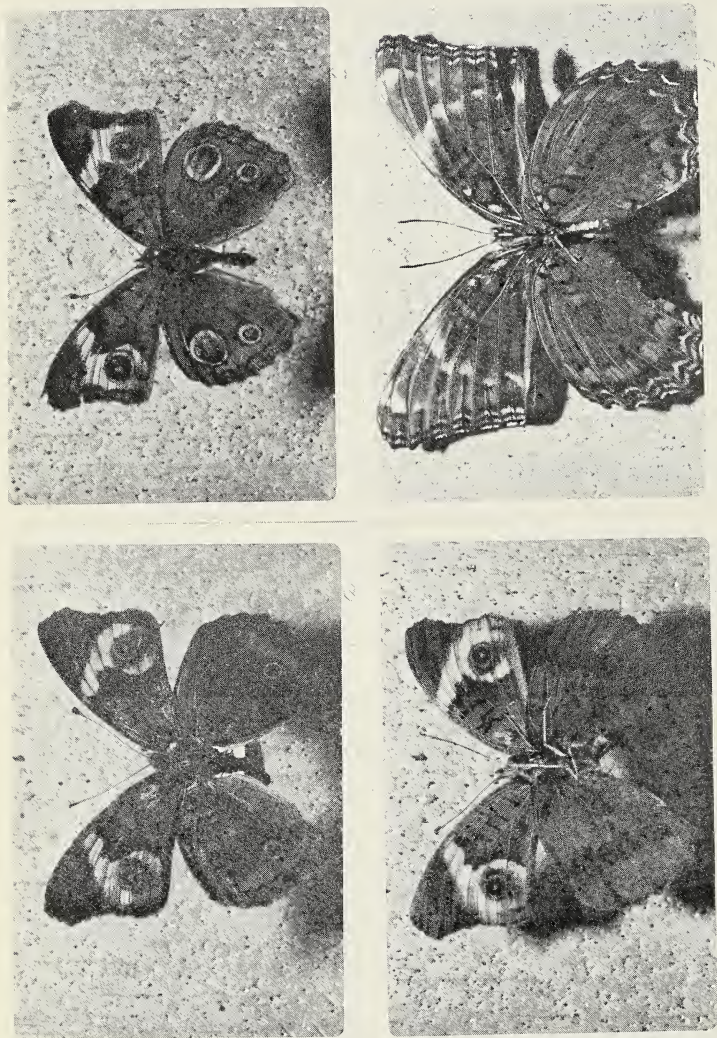


Fig. 10. a. *Precis coenia* melanic, dorsum. Midland Beach, x.26.71.
b. same specimen, ventral surface.
c. *P. coenia* with supernumerary ocellus, Midland Beach, x.18.71.
d. *Limentis astyanax* "proserpina" ♀. Tottenville, vii.14.71.

on Staten Island, and is dependent on recolonization from further south in early summer.

The "wet" form, with the hindwing infuscated with purplish-red ventrally, was common on the south and west shores in the 1971 season; some extreme specimens were taken, including a melanic with heavy black scaling covering the entire fore ocellus of the hindwing dorsally. An extremely variable species, producing many minor aberrations. A specimen with an asymmetrical supernumerary hindwing ocellus was taken x.18.71.

HOST PLANTS. Larvae common on ribbed or English plantain (*Plantago lanceolata*) (South Beach).

RECORDS: New Springville, ix.20.70; Great Kills, ix.23.70, ix.26.70, x.7.70, ix.24.71; Wolfe's Pond Park, x.24.70; Port Richmond, xi.1.70, xi.2.71; South Avenue, Travis, vii.12.71; Tottenville, vii.14.71, ix.6.71, x.6.71; Midland Beach, vii.15.71, ix.8.71, ix.15.71, x.4.71, x.19.71, x.26.71 (melanic), x.29.71, xi.6.71; Fox Hills, ix.16.71, x.12.71; Annadale, ix.25.71; Travis, ix.29.71; Oakwood, x.5.71, x.28.71 (2 abnormal); Saint George, x.14.71; New Dorp, x.21.71. (vii.12-xi.6)

27. *Limenitis astyanax* Fabricius. (*L. arthemis astyanax*) Red-Spotted Purple (Fig. 10d)

Infrequent, local, in disturbed thickets and hedgerows, but not seen on acid or serpentine soils. Davis apparently found this species much commoner than it is today: "occasional in May, a few in June, common in late July and throughout August, and a few in September." He also records a female of form *albofasciata*, Woodrow, vii.25.07. A female of form *proserpina*, with traces of the white band beneath, was taken at Tottenville, vii.14.71.

At Midland Beach this species was fairly numerous among the cottonwoods behind the bungalows. The males are territorial from mid-day through mid-afternoon, perching on projecting twigs 10-15 feet above the ground.

HOST PLANTS: Associated with cottonwood and black cherry, both of which are recorded hosts elsewhere. Although this species is known to feed on oak in some localities, it has not been seen in the extensive oak woods on the Island.

RECORDS: Tottenville, vii.14.71; Midland Beach, vii.20.71, vii.15.71; Stapleton, vii.17.71.

28. *Limenitis archippus* Cramer. Viceroy

Frequent but local, in springy or marshy open places with small willows. Presumably two-brooded. ("June to September inclusive . . . October 9, 1887") (Davis). The males are highly territorial in mid-afternoon, patrolling 6-10 feet lengths of roadside ditches.

No Staten Island specimens of the very dark-colored form seen at Philadelphia late in the season have been encountered.

HOST PLANTS: Willow (*Salix nigra*) (larvae, Tottenville). Probably poplars and aspens (*Populus* spp.).

RECORDS: Fox Hills, vii.31.70; Travis, vii.12.71; Tottenville, vii.14.71, vii.28.71, viii.18.71; South Avenue, Bloomfield, viii.16.71.

29. *Asterocampa celtis* Boisduval and LeConte. Gray Emperor

Locally abundant at Tottenville and occasional elsewhere, always in groves of the host plant and seldom straying more than a few feet from it. Territorial males perch up to 15 feet above the ground and "defend" a very large area. Both sexes move very abruptly and often pitch upward onto the undersides of leaves, as well as onto people, automobiles, etc.

Two broods, July and September. It is curious that Davis never recorded this distinctive species from the Island.

HOST PLANTS: Hackberry (*Celtis occidentalis*) (larvae, Tottenville).

RECORDS: Wolfe's Pond Park, x.24.70; Mariner's Harbor, vii.1.71; Tottenville, x.5.70, vii.3.71, vii.5.71, vii.14.71, viii.18.71, ix.6.71, ix.22.71.

LIBYTHEIDAE

30. *Libytheana bachmannii* Kirtland. Snout Butterfly

Rare and sporadic, mainly occurring on the south shore. Brush and hedgerows, especially near streams. "Two seen on August 11, 1888 (Richmondtown)" (Davis). Probably breeding here, but its overwintering status is unknown.

HOST PLANTS: Presumably hackberry, as elsewhere.

RECORDS: Great Kills, ix.23.70; Wolfe's Pond Park, x.24.70; Tottenville, vii.14.71.

LYCAENIDAE

31. *Panthiades m-album* Boisduval and LeConte. White M Hair-streak

A single record of this southern species—a fresh male. Status unknown; the White M Hairstreak breeds occasionally in southern Pennsylvania and may do so sporadically here. Recorded north to Connecticut. Borders of oak woods elsewhere.

RECORDS: Oakwood, x.5.71.

32. *Calycopsis cecrops* Fabricius. Red-Banded Hairstreak

Frequent to locally common in the lowlands, mainly in brush on acid sand and visiting roadside flowers. Probably two broods, July and September. Unrecorded by Davis or others before 1950, but now reported from various places in the metropolitan area; perhaps a recent range extension.

HOST PLANTS: Probably winged sumac (*Rhus copallina*) as on Long Island.

RECORDS: Stapleton, vii.1.71; Mariner's Harbor, vii.31.71; Tottenville, viii.18.71, ix.6.71, ix.22.71; Annadale, ix.25.71; South Beach, x.8.71; Midland Beach, x.29.71.

33. *Strymon melinus* Hubner. Gray Hairstreak

Common and general in open places, including vacant lots. Continuously brooded, three or four broods from late April to late October ("May to September," Davis). Spring individuals are small and very dark, but no such tendencies appear in the late fall ones. Our commonest hairstreak, and found in the widest range of habitats.

HOST PLANTS: Clovers (*Trifolium repens*, *T. arvense*) (ova, Port Richmond and Travis, respectively), bush clover (*Lespedeza capitata*) (ova, larvae, Bloomfield, Midland Beach), sweet clover (*Melilotus alba*) (ova, South Beach), probably other legumes.

RECORDS: Fox Hills, vii.31.70, ix.11.70; New Springville, ix.20.70; Buck's Hollow, x.1.70; Tottenville, x.5.70, vii.3.71, vii.14.71, vii.28.71, viii.18.71, ix.6.71; Port Richmond, x.23.70, iv.24.71; South Avenue, Chelsea, vii.2.71, vii.12.71, viii.16.71; Huguenot, vii.3.71; Arden Heights, vii.5.71; Sea View, vii.16.71, viii.30.71; Midland Beach, vii.20.71, viii.15.71, ix.15.71, x.26.71, x.29.71; Stapleton, viii.17.71, ix.7.71; West New Brighton, ix.21.71; Great Kills, ix.24.71; Travis, ix.29.71; Oakwood, x.5.71, x.28.71; Saint George, x.14.71; New Dorp, x.21.71. (iv.24-x.29)

34. *Harkenclenus titus* Fabricius. Coral Hairstreak

Frequent, locally common on acid sand scrub with small cherries and chokeberries, one brood in July. The males are territorial, perching 2-5 feet

from the ground on tall weeds or twigs. Not seen in the uplands, except one record in Buck's Hollow.

HOST PLANTS: *Prunus serotina*? *Aronia melanocarpa*?

RECORDS: Mariner's Harbor, vii.1.71; Richmond Valley, vii.3.71; Buck's Hollow, vii.4.71; Travis, vii.12.71; South Avenue, Chelsea and Bloomfield, vii.12.71, vii.22.71, vii.27.71; Willowbrook, vii.21.71.

35. *Satyrrium acadica* Edwards. Acadian Hairstreak

Very local, known from two marshy spots at Tottenville and one at Willowbrook, associated with *Salix nigra*. A northern species, at or near the southern limit of its range on the coastal plain, not recorded by Davis, and in New Jersey only in the Appalachian highlands (Comstock, 1940). One brood, a bit later than its congeners?

HOST PLANTS: Probably *Salix nigra*, but early stages not seen.

RECORDS: Tottenville, vii.14.71; Willowbrook, vii.21.71.

36. *Satyrrium edwardsii* Grote and Robinson. Edwards' Hairstreak

Apparently rare; one taken on acid barrens, South and Merrill Aves., Bloomfield. Should be sought in Woodrow in late June; characteristically emerges a week before the next three species.

HOST PLANTS: Everywhere associated with scrub oak (*Quercus ilicifolia*). This plant was present at the Island collection site.

RECORDS: South Avenue, Bloomfield, vii.12.71.

37. *Satyrrium falacer* Godart. Banded Hairstreak.

Abundant in upland oak woods and extremely abundant on dry acid sand on the west shore; absent from swamp (pin oak) forest. One brood, July. Males are territorial in sunlit glades in oak woods but show no aggression when large numbers are densely packed on milkweed or sumac blossoms. This species shows considerable minor color and pattern variation.

HOST PLANTS: Associated with white and chestnut oaks (*Quercus alba* and *Q. prinus*).

RECORDS: South Ave., Arlington to Travis, vii.2.71, vii.12.71, vii.22.71; Huguenot, vii.3.71; Richmond Valley, v-i.3.71; Tottenville, vii.3.71, vii.5.71, vii.14.71; Buck's Hollow, vii.4.71; Arden Heights, vii.5.71; Mariner's Harbor, vii.15.71; Willowbrook, vii.16.71, vii.21.71; often by thousands were found. (vii.2-vii.22)

38. *Satyrrium caryaevorus* McDunnough. Hickory Hairstreak

Abundant, with the last, usually a bit less numerous but by far the commonest *Satyrrium* on acid sand at Tottenville. Habits as in the last.

HOST PLANTS: Unrecorded locally.

RECORDS: South Avenue, Arlington to Travis, vii.2.71, vii.12.71; Huguenot, vii.3.71; Richmond Valley, vii.3.71; Tottenville, vii.3.71, vii.5.71, vii.14.71; Buck's Hollow, vii.4.71; Arden Heights, vii.5.71; Willowbrook, vii.16.71, vii.21.71 (vii.2-vii.21)

39. *Satyrrium liparops* Boisduval and LeConte. Striped Hairstreak

Abundant locally in brush on moist acid sand, closely associated with chokeberry. Males are territorial, perching atop chokeberry bushes. Often on flowers with the two preceding species.

A few individuals have large orange patches above on all wings, resembling the southern populations, but many are as dark as *falacer*.

HOST PLANTS: Black chokeberry (*Aronia melanocarpa*) (ova, Bloomfield), females very often roused by beating this plant.

RECORDS: South Avenue, Bloomfield, Chelsea, and Travis, vii.2.71, vii.12.71, vii.22.71, vii.27.71; Richmond Valley, vii.3.71; Tottenville, vii.4.71, vii.14.71, vii.28.71; Mariner's Harbor, vii.15.71; Willowbrook, vii.16.71, vii.21.71; Arden Heights, vii.5.71. (vii.2-vii.28)

40. *Mitoura gryneus* Hubner. Olive Hairstreak

Extinct, its food plant (*Juniperus virginiana*) reduced to less than a dozen native specimens. "Watchogue, May 8, 1881" (Davis); probably was two-brooded as elsewhere. There are no known extant Staten Island specimens of this hairstreak.

41. *Incisalia augustinus* Westwood. Brown Elf

Status uncertain. "April and May, formerly common at Watchogue and other sandy portions of the Island, but less plentiful in recent years" (Davis, 1910). A typical Pine Barrens species, looked for but not taken in 1971; specimens, either this species or *I. henrici*, were seen at Chelsea, v.15.71, Mariner's Harbor, v.27.71, and Buck's Hollow, v.5.71. Numbers possibly diminished by the high incidence of fires. In the Pine Barrens, recolonization of burned areas is simple since populations are numerous in the vicinity; the limited habitats on Staten Island make recolonization more difficult, if possible at all.

42. *Incisalia irus* Godart. Frosted Elf

"April and May . . . Watchogue, near Four Corners, Todt Hill and in the woods between the Black Horse Tavern and Richmond (town)." Frequent on acid sand, near the host plant. Should be looked for in Huguenot and along the Spring Street pipeline cut on Todt Hill, near Reed's Basket Willow Swamp. Brushy borders of woods. One brood.

HOST PLANT: *Baptisia tinctoria* (ova, Bloomfield). The wild indigo is abundant in places along the disturbed embankment of the West Shore Expressway, and *I. irus* can be expected to colonize it if it is not mowed.

RECORDS: South Avenue, Bloomfield and Chelsea, iv.18.71, v.12.71, v.15.71; Mariner's Harbor, iv.21.71.

43. *Incisalia niphon* Hubner. Pine Elf

"Common on May 8, 1881, along a sandy road at Watchogue. None have been seen since." Almost certainly extinct, its food plants (hard pines, *Pinus rigida* and *P. virginiana*) being reduced to scattered relict trees on the west shore. A univoltine Pine Barrens species. April-June.

44. *Lycaena phlaeas americana* Harris. American Copper

"May to October inclusive" (Davis). Frequent but local on poor and sandy soils. Acid sand, beach sand, and serpentine. Abundant on the mowed meadows at Mount Loretto (Pleasant Plains). Multiple (probably three) broods. The "smeared" form, *fasciata*, taken on South Avenue, v.27.71, and at Tottenville, vii.28.71.

Males are very "pugnacious," attacking even monarchs and large fritillaries.

HOST PLANT: Sheep sorrel (*Rumex acetosella*) (ova, larvae, Midland Beach, Sea View, Pleasant Plains, Port Richmond).

RECORDS: Pleasant Plains, v.10.71, vii.3.71; South Avenue, Chelsea, v.15.71, v.27.71, vii.2.71, vii.12.71; Huguenot, v.26.71; Sea View, vii.4.71, viii.20.71; Charleston, vii.5.71; Willowbrook, vii.16.71; Midland Beach, x.4.71, x.19.71. (v.10-x.19)

45. *Lycaena thoe* Guerin. Bronze Copper

Locally frequent. Wet meadows and marshes, but not noted on the bogs. Two broods, July and September. Davis found this species rare: Clove Valley, vi.20.96, New Springville, ix.12.97; Chelsea, viii.12.10.

HOST PLANT: Associated with curled dock, *Rumex crispus*, in low places. RECORDS: Travis, vii.12.71; Tottenville, vii.14.71, ix.6.71, ix.22.71; Mariner's Harbor, vii.15.71; Willowbrook, vii.21.71; Graniteville, viii.14.71.

(The Bog Copper, *Lycaena epixanthe* Boisduval and LeConte, was not recorded by Davis but probably formerly occurred on the bogs. It is common on Long Island and in the New Jersey Pine Barrens.)

46. *Everes comyntas* Godart. Tailed Blue

Abundant, waste ground, weedy roadsides, dry old fields and acid scrub, May-late October; at least three broods. Spring forms are large and bright, females with much blue; summer and autumn females brown or black. Males "pugnacious."

HOST PLANTS: *Desmodium canadense* (ova, larvae, Todt Hill); *Lespedeza capitata* (ova, Chelsea); *Trifolium repens* (ova, Port Richmond); perhaps *Melilotus*?

RECORDS: Fox Hills, vii.31.70, ix.11.70, vii.29.71, x.12.71; Willowbrook, ix.6.70; Great Kills, ix.26.70, x.7.70; Tottenville, x.5.70, vii.8.71, vii.28.71, vii.18.71, ix.22.71, x.6.71; Pleasant Plains, x.10.71; Port Richmond, v.11.71, viii.17.71, ix.3.71, ix.12.71; South Avenue, Arlington to Bloomfield, v.12.71, v.15.71, v.27.71, vii.2.71, vii.22.71, vii.27.71, viii.16.71; Stapleton, v.17.71, vii.1.71, ix.7.71; Mariner's Harbor, vii.1.71, vii.15.71, viii.14.71, x.1.71; Todt Hill, v.18.71; Huguenot, v.26.71; Sea View, vii.4.71, vii.16.71, x.30.71; Charleston, vii.5.71; Midland Beach, vii.20.71, ix.15.71; West New Brighton, ix.21.71; Annadale, ix.25.71; Travis, ix.29.71; Oakwood, x.5.71; Richmondtown, x.13.71; Saint George, x.14.71; New Dorp, x.21.71 (v.11-x.30)

47. *Lycaenopsis argiolus* Linnaeus. Spring Azure

Davis records all three spring forms from the Island, and gives a seasonal range of March to September. In 1971 only one spring specimen (a female *violacea*) was seen although all suitable habitats were searched. The spring flight in Westchester County at the same time was normal. The same situation occurs at Tinicum, near Philadelphia, where summer forms are common but the spring brood is rare or absent. A female *marginata* was, however, taken out of season at Tottenville, ix.6.71.

Summer forms common and widespread in brush, open woods, and gardens; common on overgrown slopes in Stapleton. Probably two summer generations.

HOST PLANTS: Unrecorded on the Island. Flowering dogwood, the usual Piedmont host in spring, is very rare in the wild but maple-leaved viburnum, *V. acerifolium*, and other shrubby viburnums and dogwoods are common in various habitats.

RECORDS: Fox Hills, vii.31.70; Todt Hill, v.14.71; Tottenville, vii.3.71, vii.14.71, vii.28.71, viii.18.71, ix.6.71, ix.22.71; Buck's Hollow, vii.4.71; South Avenue, Bloomfield, vii.12.71, vii.27.71; Mariner's Harbor, vii.15.71; Sea View, vii.16.71; Midland Beach, vii.20.71, viii.15.71, ix.15.71; Stapleton, vii.22.71, viii.17.71. (v.14-ix.22)

LIPHYRIDAE

48. *Feniseca tarquinius* Fabricius. Harvester

Frequent but sporadic, in wet shrubby sites mainly on acid soils; the males defend territories from perches up to 10 feet from the ground on sunlit twigs or leaves and return persistently to the same site when dis-

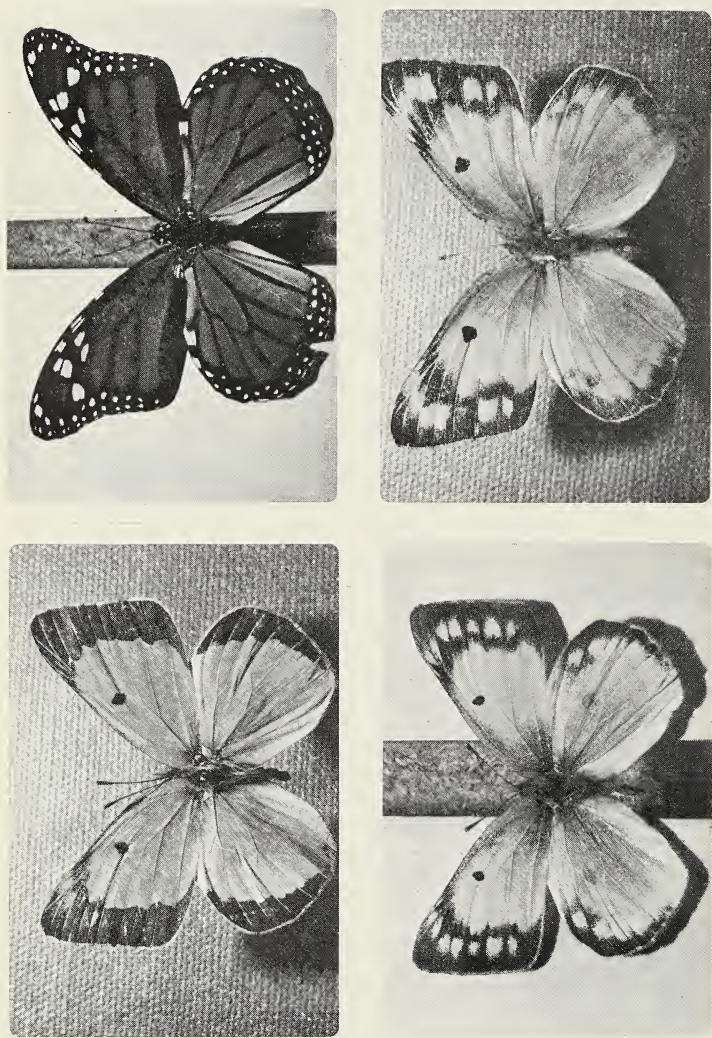


Fig. 11. a. *Colias eurytheme* mosaic gynandromorph, Tottenville, vii.14.71.
 b. *C. eurytheme* "blonde", ♀ Oakwood, x.28.71.
 c. *Danaus plexippus* "megallippe"-like ♀, Willowbrook, ix.6.70.
 d. *C. eurytheme* "chrome yellow", ♀, Tottenville, vii.14.71.

turbed. At least two broods, probably more. "June 21, 1885; August 4, 1907; Woodrow, August 21, 1910."

HOST: Not recorded on Staten Island. Alder, the usual host of the woolly aphids eaten by *F. tarquinius*, is nearly extinct here. Perhaps on woolly aphids of beech or ash.

RECORDS: South Avenue, Chelsea, vii.22.71, viii.16.71; Tottenville, viii.18.71, ix.22.71; Annadale, ix.25.71.

PAPILIONIDAE

49. *Papilio polyxenes asterius* Stoll. Black Swallowtail

"May to October inclusive," Davis. Common and widespread in open meadows, fields and marshes. The territorial males hilltop and "fly a beat." Extremely variable, individually and seasonally, varying particularly in the width and position of the postmedian yellow hindwing band in the male. Partially triple-brooded.

This species fluctuates greatly in numbers; 1971 was probably a peak year.

HOST PLANTS: Wild carrot (*Daucus carota*) (ova, larvae, many stations).

RECORDS: Fox Hills, vii.31.70, vii.29.71; New Springville, ix.20.70; Travis, v.5.71; Port Richmond, v.11.71, viii.17.71; South Avenue, Chelsea, v.12.71, vii.2.71, vii.12.71, vii.22.71, vii.27.71, viii.16.71; Todt Hill, v.14.71; Huguenot, v.26.71; Mariner's Harbor, vii.1.71; Sea View, vii.4.71, viii.30.71; Port Ivory, vii.15.71; Midland Beach, vii.20.71; Willowbrook, vii.21.71; Stapleton, vii.22.71; Oakwood, x.5.71. (v.5-x.5)

50. *Papilio glaucus* Linnaeus. Tiger Swallowtail

"May to September inclusive." Frequent to common in open woods, straying widely, commoner on non-acid soils. No fully black females were taken, but two transitional ones were (Arden Heights, vii.5.71; Tottenville, ix.6.71). Double-brooded, the spring flight partly of form "*canadensis*" (Huguenot, v.26.71). The least common of the resident swallowtails on the Island in 1971, but down from 1970 levels.

HOST PLANTS: Black cherry (*Prunus serotina*) (larva, Travis); lilac (*Syringa vulgaris*) (larva, Tompkinsville).

RECORDS: Fox Hills, vii.31.70; Stapleton, v.17.71; Todt Hill, v.18.71; Huguenot, v.26.71; Mariner's Harbor, vii.1.71, viii.14.71; South Avenue, Bloomfield, vii.2.71, vii.12.71; Port Richmond, vii.4.71; Arden Heights, vii.5.71; Willowbrook, vii.21.71; Midland Beach, viii.15.71; Tottenville, viii.18.71, ix.6.71. (v.17-ix.6)

51. *Papilio troilus* Linnaeus. Spicebush Swallowtail

"May to September inclusive" (Davis). Abundant and general in open woods and brush, particularly on acid soils and serpentine; straying to gardens. Exceedingly variable, with a tendency to enlargement of the submarginal spots and to colored tails. Two broods, males of the second with the apical hindwing spot mostly pale green rather than orange above. An avid flower visitor and mud puddle butterfly. Seen in copula at Tottenville, vii.28.71 and viii.18.71, 2:40 and 3:20 PM.

HOST PLANTS: Sassafras (*S. albidum*) (larvae abundant, Stapleton); presumably also spicebush (*Lindera benzoin*).

RECORDS: Fox Hills, vii.31.70; Todt Hill, v.14.71; Tottenville, v.25.71, vii.14.71, vii.28.71, viii.18.71, ix.6.71; Huguenot, v.26.71, vii.3.71; Mariner's Harbor, vii.1.71, vii.31.71, viii.14.71; South Avenue, Arlington to Travis, vii.2.71, vii.12.71, vii.22.71, viii.16.71; Buck's Hollow, vii.4.71; Arden Heights, vii.5.71; Port Ivory, vii.15.71; Midland Beach, vii.20.71; Willowbrook, vii.21.71; Wolfe's Pond Park, viii.2.71; Stapleton, viii.17.71. (v.14-ix.6)

52. *Papilio palamedes* Drury. Palamedes Swallowtail

A very rare stray, recorded by Comstock (1940) citing as his source Davis; Fort Wadsworth, vi.18.? (leg. Edward J. Burns). The deposition of the specimen is unknown. The only record north of Cape May, N.J.; this butterfly is not known to breed north of the outer coastal plain of Virginia.

53. *Papilio cresphontes* Cramer. Giant Swallowtail

No modern records. "August and September, 1882 . . . a few in 1893. Since that date, it has been observed in the Moravian Cemetery (New Dorp), where there are some bushes of *Ptelea trifoliata*, the food plant of the larva" (Davis). The northern boundary for this species expands and contracts irregularly and it could colonize the metropolitan area again. Two broods near Philadelphia.

54. *Battus philenor* Linnaeus. Pipevine Swallowtail

Rare immigrant. Perhaps colonizing the Island at times though rarely, if ever, overwintering. May 6-November 2 (Davis). There are no native host plants on the Island, and Dutchman's Pipe (*Aristolochia* sp.) is not a very common ornamental.

RECORDS: South Avenue, Bloomfield, vii.22.71; Tottenville, ix.6.71; Mariner's Harbor, x.1.71.

55. *Graphium marcellus* Linnaeus. Zebra Swallowtail

There are no modern records of this species or its food plant (Pawpaw, *Asimina triloba*) anywhere near New York City. Davis gives four records: Bull's Head, vii.5.86; Old Place, vi.30.89; Tottenville, vi.14.02; Concord, viii.5.02.

PIERIDAE

56. *Colias eurytheme* Boisduval. Orange Sulphur, Alfalfa Butterfly (Figs. 11a, b, d)

The most abundant butterfly on Staten Island. Open, disturbed, weedy sites, including dumps, vacant lots, and railroad yards. At least four broods from May to early December; in 1971, the flight continuing well into the winter. Rare in New York City area before about 1930; Davis gives one record of a stray (Richmondtown, October 20, 1900). Mr. Joseph F. Burke took a female in Van Cortlandt Park, New York City, on vii.31.29, now in the S.I. Museum. Well established by 1933, when it flew until November 22 (Davis, 1934).

The short-day phenotype ("*ariadne*") is common in May and after mid September. Aberrant specimens occur frequently. A mosaic gynandromorph, male but with the apex of the left forewing female, was taken at Tottenville (vii.14.71). "Blonde" and "semialba" females (the former uniform ochreous white, the latter white with an orange discal flush) occur along with the usual white ("alba") ones; the frequency of "alba" is lowest in spring and highest in September and October, which is also the time of peak populations. Hybrids with *Colias philodice* constitute about 8% of captures, not counting "alba" females whose color genotype is concealed. Overwinters as the larva, continuing to feed on mild days and often pupating before spring.

HOST PLANTS: Clovers (*Trifolium pratense*, *repens*); Sweet clover (*Melilotus alba*); vetch (*Vicia*) (Chelsea, Old Place); alfalfa (*Medicago sativa*) (Willowbrook); all based on numerous collections or observations of ova and larvae.

RECORDS: Fox Hills, vii.31.70, ix.11.70, vii.29.71, ix.16.71, x.12.71, xi.16.71, xi.28.71, xii.10.71, xii.11.71, xii.13.71; Port Richmond, ix.7.70, x.19.70, x.20.70, x.23.70, x.24.70, xi.1.70, xi.3.70, xi.8.70, xi.9.70, xi.14.70, xi.19.70, xi.21.70, xii.2.70, viii.17.71, ix.12.71, xi.2.71, i.4.72; Richmondtown, ix.13.70, x.13.71; New Springville, ix.20.70; Great Kills, ix.23.70, ix.26.70, ix.24.71; Buck's Hollow, x.1.70; Tottenville, x.5.70, vii.5.71, vii.14.71, vii.28.71, viii.18.71, x.6.71; Wolfe's Pond Park, x.24.70, viii.2.71; Graniteville, x.28.70; Old Place, xi.7.70; South Avenue, Chelsea, v.5.71, v.12.71, v.15.71, vii.2.71, vii.12.71, vii.22.71, viii.16.71; Travis, v.5.71, ix.29.71; Pleasant Plains, v.10.71, vii.3.71; Todt Hill, v.14.71, vii.4.71; Stapleton, vii.1.71, viii.17.71, ix.7.71, xi.5.71; Mariner's Harbor, vii.1.71, vii.15.71, x.1.71, x.27.71; Charleston, vii.5.71; Sea View, vii.16.71, viii.30.71, x.30.71; Willowbrook, vii.21.71, x.16.71; Midland Beach, vii.15.71, ix.8.71, ix.15.71, x.4.71, x.19.71, x.26.71, x.29.71, xi.4.71, xi.6.71, xi.17.71, xi.28.71, xii.16.71; West New Brighton, ix.21.71; Annadale, ix.25.71; Oakwood, x.5.71, x.28.71, xi.18.71; South Beach, x.8.71, xi.19.71; Saint George, x.14.71; New Dorp, x.21.71; Fort Wadsworth, xii.16.71, xii.21.71, i.3.72. Form "alba" at virtually all stations, dates v.12.71-xii.2.70. "Blonde" females, Fox Hills, vii.31.70 (in Cornell University collections); Midland Beach, ix.5.71; Oakwood, x.28.71. "Semi-alba" females common after mid-vii. Hybrids, both sexes, collected as follows: New Springville, ix.20.70; Great Kills, ix.23.70, ix.24.71; Port Richmond, x.24.70, xi.1.70, xi.8.70, xi.9.70, xi.14.70, v.11.71, xi.2.71; Travis, v.5.71; Todt Hill, v.14.71; South Avenue, Chelsea, v.15.71, vii.2.71, vii.12.71, vii.22.71, vii.27.71; Mariner's Harbor, vii.15.71, x.1.71; Tottenville, vii.27.71; Midland Beach, viii.15.71, ix.15.71; Fox Hills, ix.16.71; Annadale, ix.25.71; New Dorp, x.21.71. (v.5-i.4)

57. *Colias philodice* Latreille. Common or Yellow Sulphur

Common and widespread in open country, preferring moister sites than the more abundant Orange Sulphur. "April-December 6 (1891)" (Davis). Probably four broods. For hybrids, see under *C. eurytheme*, above. The short-day phenotype ("*anthyale*") well-developed in April-May and September-November. White females not always distinguishable from the preceding; more frequent than white *eurytheme* in spring? A "chrome yellow" female with the pattern of *eurytheme*, taken at Tottenville vii.14.71, is probably that species rather than *philodice*.

HOST PLANTS: Clovers (*Trifolium repens* and *pratense*) (many records; ova, larvae); perhaps other legumes.

RECORDS: Fox Hills, vii.31.70, ix.11.70, iv.24.71, vii.29.71, ix.16.71, x.12.71; Great Kills, ix.26.70, ix.24.71; Port Richmond, x.20.70, xi.1.70, xi.3.70, xi.8.70, xi.14.70, ix.24.71, v.11.71, ix.12.71; Wolfe's Pond Park, x.24.70; Graniteville, x.28.70; Old Place, xi.3.70; Eltingville, ix.25.71; South Avenue, Chelsea and Bloomfield, v.5.71, v.12.71, v.15.71, vii.2.71, vii.12.71, vi.22.71, vii.27.71; Travis, v.5.71, ix.29.71; Pleasant Plains, v.10.71, vii.3.71; Todt Hill, v.14.71, vii.4.71; Stapleton, vii.1.71, ix.7.71; Mariner's Harbor, vii.1.71, vii.15.71, x.1.71; Buck's Hollow, vii.4.71; Charleston, vii.5.71; Willowbrook, vii.16.71, vii.21.71; Midland Beach, vii.20.71, ix.15.71, x.4.71, x.19.71, x.26.71, x.29.71; Annadale, ix.25.71; Oakwood, x.5.71; Tottenville, x.6.71; Richmondtown, x.13.71; New Dorp, x.21.71; Sea View, x.30.71. Dates for form "alba," iv.24.71-x.26.71. (iv.24-xi.14)

58. *Colias (Zerene) caesonia* Stoll. Dog Face

The only records near New York City are given by Davis: Eltingville and Kreischerville (=Charleston), summer 1896, apparently frequent and perhaps breeding. This southern species occasionally immigrates into the northeast and may set up temporary colonies there, but cannot overwinter. The usual food plant, *Amorpha*, grows today in Woodrow and Willowbrook.

59. *Phoebis sennae eubule* Linnaeus. Cloudless Sulphur

No modern records. "Usually appears in September about the middle of the month, and in some years is quite common. Two specimens . . . at Tottenville, October 4, 1903." A coastal migrant recorded in numbers north to eastern Massachusetts; regularly reaching the New Jersey shore in autumn. Should be looked for on the south shore beaches. Not known to breed north of Virginia.

60. *Eurema nicippe* Cramer. Sleepy Orange

Irregular immigrant, breeding often, but its overwintering status in doubt. In 1971 at least two broods on the sandy west shore from Mariner's Harbor to Tottenville. Davis records flights in 1880, 1891, 1896, 1906, 1907, and 1910, May-October, breeding in the Clove Valley on *Cassia marilandica* (this plant is not known at present on Staten Island). His surviving specimens are dated v.10.96, vi.24.06, x.4.91, v.30? and "1880."

HOST PLANTS: Perhaps partridge peas (*Cassia nictitans*).

RECORDS: Mariner's Harbor, vii.1.71; Charleston, vii.5.71; South Avenue, Bloomfield, vii.12.71, vii.22.71; Tottenville, ix.22.71.

61. *Eurema lisa* Boisduval and LeConte. Little Sulphur

"July to October inclusive. Most common on the sandy portions of the Island" (Davis). Common and widespread in open sandy fields and beaches, 1970, but completely absent in 1971. Probably a regular immigrant, breeding but not usually overwintering. The white female form not recorded locally.

HOST PLANTS: Wild sensitive plant or partridge pea, *Cassia nictitans* (ova, larvae, Graniteville).

RECORDS: New Springville, ix.20.70; Great Kills, ix.23.70, ix.26.70, x.7.70; Buck's Hollow, x.1.70; Port Richmond, x.23.70, x.24.70, xi.1.70, xi.3.70; Wolfe's Pond Park, x.24.70.

62. *Pieris rapae* Linnaeus. European Cabbage Butterfly

Abundant and general in open places, including gardens and vacant lots. April-November, the spring and last fall specimens of the cold weather phenotype with reduced black above, but heavily dusted beneath. The female form "fasciata," with the discal forewing spots fused, taken at Oakwood, xi.5.71. In mild years probably flying as early as mid-March; "March-November," Davis. The Davis collection contains one dated III.29.03.

Probably four broods, changing host plant as the seasonal succession of weedy Cruciferae occurs.

HOST PLANTS: (All ova and larvae, many records on the Island) Cruciferae: *Lepidium virginicum*, *Barbarea vulgaris*, *Brassica nigra*, *B. oleracea*, *Eruca sativa*, *Sisymbrium officinale* var. *leiocarpum*, *S. altissimum*. Overwinters as diapausing pupae, but living larvae were found on *Barbarea* as late as i.4.72.

RECORDS: Fox Hills, vii.31.70, iv.24.71, v.24.71, x.12.71; New Springville, ix.20.70; Tottenville, x.5.70, vii.4.71; vii.28.71, x.6.71; Port Richmond, x.23.70, xi.1.70, xi.3.70, xi.8.70, ix.17.71, iv.21.71, iv.24.71, v.5.71, ix.3.71, ix.12.71, ix.27.71, xi.2.71; Wolfe's Pond Park, x.24.70; Graniteville, x.28.70; Old Place, xi.7.70; Mariner's Harbor, iv.11.71, vii.2.71, viii.14.71, x.27.71; Travis, iv.18.71, v.5.71, ix.29.71; Stapleton, iv.19.71, iv.24.71, v.17.71, vii.1.71; South Avenue, Bloomfield, v.5.71, v.15.71, v.27.71, vii.22.71; Latourette Park, v.5.71; Pleasant Plains, v.10.71; Todt Hill, v.14.71; Port Ivory, vii.15.71; Sea View, vii.16.71, x.30.71; Midland Beach, vii.20.71, vii.15.71, ix.8.71, ix.15.71, x.4.71, x.19.71, x.26.71, x.29.71, xi.4.71, xi.6.71, xi.17.71; Willowbrook, vii.21.71, x.16.71; West New Brighton, ix.21.71; Great Kills, ix.24.71; Annadale, ix.25.71; Oakwood, x.5.71, x.28.71, xi.5.71; South Beach, x.8.71; Richmondtown, x.13.71; Saint George, x.14.71; New Dorp, x.21.71. (iv.11-xi.17)

63. *Pieris protodice* Boisduval and LeConte. Checkered White

June-September, and April 19, 1902 (Davis records). Locally common to abundant on disturbed sandy soils, most numerous on the coastal plain and absent from the hills. April-November, the short-day phenotype (*vernalis* Edwards) at both ends of the flight; four broods, perhaps not always

wintering successfully even on the south shore, and in any case certainly bolstered by immigration. The Davis collection contains Island specimens dated viii.27 and ix.6 (no year) and a female *vernalis*, x.15.12.

HOST PLANTS: Peppergrass (*Lepidium virginicum*) (many ova and larvae, Midland Beach).

RECORDS: New Springville, ix.20.70; Great Kills, ix.23.70, ix.24.71; Wolfe's Pond Park, x.24.70; Graniteville, x.28.70; Port Richmond, xi.1.70, xi.9.70, iv.21.71; Stapleton, iv.19.71; South Avenue, Chelsea, viii.16.71; Midland Beach, ix.8.71, ix.15.71, x.4.71, x.19.71, x.26.71, xi.17.71, xi.28.71; West New Brighton, ix.21.71; Tottenville, ix.22.71, x.6.71; Annadale, ix.25.71; Travis, ix.29.71; Oakwood, x.5.71, xi.18.71; South Beach, x.8.71, xi.19.71; Fox Hills, x.12.71. (iv.19-xi.28)

(The Falcate Orange Tip, *Anthocaris midea* Hubner, while frequent in upland woods north of New York City and also in the Pine Barrens, has never been recorded from Staten Island.)

HESPERIIDAE

64. *Epargyreus clarus* Cramer. Silver-Spotted Skipper

Common and general in brushy open woods or thickets, wherever small plants of the host grow. Strays to gardens. Larvae common, the easiest skipper larvae to find. Males are territorial, adopting perches 3-10 feet above the ground.

Two broods, May and August.

HOST PLANTS: Black locust (*Robinia pseudoacacia*) (larvae, Stapleton, Charleston).

RECORDS: Fox Hills, vii.31.70; Huguenot, v.26.71, vii.3.71; Stapleton, vii.1.71, ix.7.71; South Avenue, Chelsea, vii.2.71, viii.16.71, ix.1.71; Sea View, vii.16.71; Willowbrook, vii.21.71; Tottenville, vii.28.71, ix.6.71; Port Richmond, viii.17.71. (v.26-ix.7)

65. *Achalarus lycidas* Geyer. Hoary Edge

Locally common on sandy soils with the food plants, in both upland and lowland situations in brushy fields and open woods. Males territorial, seldom perching more than four feet high. One brood, "May, June, July" (Davis).

HOST PLANTS: *Desmodium* species (larvae, Todt Hill; ova, Huguenot).

RECORDS: Stapleton, vii.1.71; South Avenue, Bloomfield, vii.2.71; Huguenot, vii.3.71; Tottenville, vii.3.71, vii.14.71; Todt Hill, vii.4.71; Buck's Hollow, vii.4.71; Willowbrook, vii.21.71.

66. *Thorybes pylades* Scudder. Northern Cloudy Wing

One record on acid scrub. The usual food plants, *Lespedeza* and *Desmodium*, are common and 1971 may have been a poor year for the species. Should be sought on acid sand and serpentine in brush and open woods, June (-July, Davis).

RECORDS: South Avenue, Bloomfield, vii.12.71.

67. *Thorybes bathyllus* Smith and Abbott. Southern Cloudy Wing

"May, June, and July" (Davis). No modern records. A species of sandy soils, feeding on *Desmodium* (preferring *D. rotundifolium*, not seen on Staten Island). Single-brooded in central New York, double-brooded at Philadelphia. There is no obvious reason for the absence of this species today; it should be sought on the west shore in June.

68. *Pholisora catullus* Fabricius. Sooty Wing

Very common on vacant lots and by weedy roadsides, and on the Fresh Kills landfill. Infrequent elsewhere. A species closely associated with man and his works. Two broods, May and July, with a partial third in mid-late August.

HOST PLANTS: Pigweeds (*Amaranthus* spp.), Lamb's Quarters (*Chenopodium album*) (larvae common, Stapleton, Port Ivory, Charleston).

RECORDS: Fox Hills, vii.31.70, v.24.71; Stapleton, v.17.71, vii.1.71, ix.7.71; Huguenot, v.26.71; Sea View, vii.4.71, viii.16.71; South Avenue, Arlington, vii.12.71; Tottenville, vii.14.71, vii.28.71; Mariner's Harbor, vii.15.71; Midland Beach, vii.20.71, vii.15.71. (v.17-ix.7)

69. *Pyrgus communis* Grote. Checkered Skipper

"August, September, and October at Tottenville, and one near (New Springville), September 8, 1895" (Davis). No modern records. The checkered skipper is an irregular immigrant into the New York area, occasionally breeding and overwintering. Two food plants, *Malva neglecta* and garden hollyhock, *Althaea officinalis*, are common on the Island and could sustain breeding if females arrived in late summer.

70. *Erynnis icelus* Scudder and Burgess. Dreamy Dusky Wing

Frequent in brush and open woods on serpentine and acid sand. One brood, May-June. The only dusky wing which flies into dense brush when alarmed.

HOST PLANTS: Gray birch (*Betula populifolia*)? Big-tooth Aspen (*Populus grandidentata*)?

RECORDS: Todt Hill, v.14.71, v.18.71; Sea View, v.18.71; Huguenot, v.24.71; South Avenue, Bloomfield, v.27.71.

71. *Erynnis brizo* Boisduval and LeConte. Sleepy Dusky Wing

"April, May, and June, on the more barren hills and sandy districts" (Davis). A typical Pine Barrens species which should occur on the west shore lowlands, at Woodrow and at Tottenville, but not observed in 1971. Should be looked for, especially near the usual host plant, scrub oak (*Quercus ilicifolia*).

72. *Erynnis martialis* Scudder. Mottled Dusky Wing

"Clove Valley, v.3.02; Reed's Valley (Todt Hill), viii.10.09" (Davis). One taken near Susan Wagner High School, Sea View, on serpentine in open brushy woods. Should be sought near the usual host plant, *Ceanothus* (a rare plant on the Island today, noted only on Todt Hill, at Sea View, and in Huguenot). Bivoltine in New Jersey.

RECORDS: Sea View, vii.16.71.

73. *Erynnis horatius* Scudder and Burgess. Horace's Dusky Wing

Frequent in and near oak woods at all elevations. Apparently three-brooded, May to September. Unreported by Davis, probably through confusion with the next species. The only *Erynnis* seen in pin oak swamp forest.

HOST PLANTS: Not known, presumably some species of oak.

RECORDS: South Avenue, Chelsea, v.5.71, vii.12.71; Todt Hill, v.18.71; Tottenville, vii.14.71; Mariner's Harbor, vii.15.71; Stapleton, ix.7.71.

74. *Erynnis juvenalis* Fabricius. Juvenal's Dusky Wing, Common Dusky Wing

Abundant in oak woods and scrub at all elevations, but absent from pin oak swamp forest. Single-brooded, flying in May; Davis' record of "early May to October" was undoubtedly based on confusion with the preceding species. The males are territorial along wood roads. A pair taken *in copula*, Todt Hill, v.14.71 at 3:30 p.m. in shade by a roadside.

HOST PLANTS: White and post oaks (*Quercus alba*, *stellata*) (larvae, Bloomfield), perhaps other oaks.

RECORDS: South Avenue, Arlington to Travis, v.5.71, v.12.71, v.15.71, v.27.71; Latourette Park, v.5.71; Pleasant Plains, v.10.71; Todt Hill, v.14.71, v.18.71.

75. *Erynnis baptisiae* Forbes. Wild Indigo Dusky Wing

Infrequent, sporadic. Brushy sites on acid sand or serpentine, but not noted as especially frequenting the vicinity of the supposed host plant, *Baptisia*; visits dogbane and other roadside flowers. Two broods, May and July. Davis' specimens are lost, but his record of *E. persius*, "May to September inclusive," almost certainly refers to this species.

HOST PLANTS: Not recorded on Staten Island.

RECORDS: Huguenot, v.26.71; Willowbrook, vii.21.71; Tottenville, vii.28.71.

76. *Ancyloxypha numitor* Fabricius. Least Skipper

Common and widespread. Wet meadows, ditches, edges of ponds and marshes, and vacant lots, often flying below the top of the grass. Two broods, July and August-October, second brood individuals generally larger and darker than first.

HOST PLANTS: Cutgrass, *Leersia oryzoides* (larvae, Travis, Sea View), probably other grasses.

RECORDS: Fox Hills, vii.31.70; Willowbrook, ix.6.70, vii.21.71; Stapleton, vii.1.71, ix.7.71; South Avenue, Chelsea, vii.12.71, vii.27.71, ix.1.71; Port Ivory, vii.15.71; Wolfe's Pond Park, viii.2.71; Midland Beach, viii.15.71; Sea View, viii.30.71; West New Brighton, ix.21.71; Mariner's Harbor, x.1.71; Tottenville, x.6.71. (vii.1-x.6)

77. *Thymelicus lineola* Ochseneheimer. European Skipper

Common to locally abundant in grassy meadows, old fields, and vacant lots; absent from serpentine barrens. Most numerous at Mount Loretto, visiting bird's-foot trefoil blossoms. A recent introduction in the New York City area (Shapiro, 1971). The white form has not been observed. One brood, June-July.

HOST PLANTS: Timothy (*Phleum pratense*) (ova, Pleasant Plains), perhaps other introduced grasses.

RECORDS: Stapleton, vii.1.71; Mariner's Harbor, vii.1.71; South Avenue, Arlington, vii.2.71; Pleasant Plains, vii.3.71; Tottenville, vii.3.71; Sea View, vii.4.71; Arden Heights, vii.5.71; Port Ivory, vii.15.71.

78. *Hesperia sassacus* Harris. Indian Skipper

"May and June" (Davis). Not seen in 1971. Should be looked for on serpentine barrens and on sandy soils.

79. *Hesperia leonardus* Harris. Leonard's Skipper

"One female collected at Mariner's Harbor on September 25, 1887 and one male on Todt Hill, September 22, 1888." One modern record, taken on a Joe-Pye weed blossom in brush along Clermont Avenue, Tottenville.

Should be fairly widespread on acid soils. Single-brooded throughout its range, in late summer.

RECORDS: Tottenville, ix.22.71.

80. *Hesperia attalus* Edwards. Attalus Skipper

One record on serpentine barrens. A rare species; in southern New Jersey associated with extensive stands of switchgrass (*Panicum virgatum*). Breeding status unknown.

RECORDS: Sea View, vii.16.71.

81. *Hesperia metea* Scudder. Cobweb Skipper

Common or locally abundant on serpentine barrens, and less frequently on wet, acid sandy soils and around the bogs. One brood, May. The males are territorial, perching on bare ground among the tufts of bluestem. Recorded from Tottenville, June (Davis) but not seen there in 1971.

HOST PLANTS: Little bluestem (*Andropogon scoparius*) on serpentine and bunchtop bluestem (*A. glomeratus*) on bogs. On the former, larva constructs a nest of a rolled leaf or leaves at the crown; when in diapause occupies a partly subterranean nest in which it is able to withstand light ground fires, which are frequent on the barrens. (Larvae, Richmondtown, Chelsea).

RECORDS: South Avenue, Arlington to Bloomfield and Chelsea, v.12.71, v.15.71, v.27.71; Travis (on diabase), v.27.71; Richmondtown, v.18.71.

82. *Hylephila phylaeus* Drury. Fiery Skipper

Frequent after early August in a variety of open situations, even on lawns; probably a regular immigrant, overwintering rarely, if ever. Not recorded by Davis. Late-season specimens have heavier patterns on the hindwing beneath.

HOST PLANTS: Unrecorded.

RECORDS: Wolfe's Pond Park, viii.2.71; Tottenville, viii.18.71, ix.22.71; Port Richmond, ix.6.71; Midland Beach, ix.15.71, x.29.71; Graniteville, viii.17.71; Fox Hills, ix.16.71; Annadale, ix.25.71; Oakwood, x.5.71, x.28.71, xi.5.71.

83. *Atalopedes campestris* Boisduval. The Sachem

A rare stray from the south, not recorded by Davis. One record.

RECORDS: Oakwood, x.28.71.

84. *Polites verna* Edwards. Glassy Wing

"June, July, and August" (Davis). Frequent and widespread in brushy places, open woods, and old fields; usually seen on blossoms of common milkweed. One brood; the host plant not known but certainly a grass.

RECORDS: South Avenue, Chelsea and Bloomfield, vii.2.71, viii.22.71; Huguenot, vii.3.71; Pleasant Plains, vii.3.71; Tottenville, vii.4.71, vii.14.71; Charleston, vii.5.71; Arden Heights, vii.5.71; Sea View, vii.16.71, vii.21.71.

85. *Polites manataqua* Scudder. Cross-line Skipper

Frequent in dry grassy areas, locally very abundant on serpentine barrens at Sea View. Apparently single-brooded in July ("May-July," Davis), although it is clearly double-brooded at Philadelphia and partially so in central New York.

HOST PLANTS: Not recorded. Although commonly found on serpentine, this species does not seem to be an *Andropogon* feeder.

RECORDS: Stapleton, vii.1.71; South Avenue, Arlington, vii.2.71, vii.12.71; Sea View, vii.4.71, vii.16.71; Port Ivory, vii.15.71; Willowbrook, vii.16.71, vii.21.71.

86. *Polites themistocles* Latreille. Tawny-Edged Skipper

"May to September inclusive" (Davis), probably including the preceding species. Infrequent and sporadic, mostly as singletons on flowers in open grassy places, even on vacant lots growing up to asters. Two broods, July and September. Not yet found with *P. manataaqua* on Staten Island. At Philadelphia that species tends to occur upslope of *P. themistocles* where they are found contiguously.

HOST PLANTS: Unknown. Presumably a grass.

RECORDS: Latourette Park, ix.6.70; Huguenot, vii.3.71; Buck's Hollow, vii.4.71; South Avenue, Chelsea, vii.12.71; Willowbrook, vii.21.71.

87. *Polites peckius* Kirby. Peck's Skipper

Common and widespread in moist grassy sites and vacant lots, seemingly regardless of soils, but not on extensive bluestem (serpentine) barrens. Probably partially three-brooded, May to September. Host not recorded locally.

RECORDS: Richmondtown, ix.13.70; South Avenue, Arlington to Travis, v.27.71, vii.2.71, viii.16.71, ix.1.71; Stapleton, vii.1.71, viii.17.71, ix.7.71; Huguenot, vii.3.71; Pleasant Plains, vii.3.71; Tottenville, vii.14.71; Wolfe's Pond Park, viii.2.71; Mariner's Harbor, viii.14.71; Midland Beach, viii.15.71, ix.8.71; Port Richmond, viii.17.71; Sea View, viii.30.71. (v.27-ix.13)

88. *Polites mystic* Scudder. Long Dash

Scarce and local, recorded on one of the west shore bogs and in a wet meadow on acid sand; apparently one-brooded. Reported by Davis for June; not fresh in July, 1971. At the latitude of New York City, this species may be partially double-brooded, at least some years.

HOST PLANTS: Not known.

RECORDS: South Avenue, Bloomfield, vii.12.71; Tottenville, vii.14.71.

89. *Polites vibex* Geyer. Whirlabout

This southern species was a frequent immigrant on the south shore in the fall of 1971, though not seen in 1970. It flies with the similarly colored Fiery Skipper. Unreported previously for the New York area, although it fairly often reaches Philadelphia on the coastal plain. Breeding status doubtful.

RECORDS: Tottenville, viii.18.71, ix.22.71; Midland Beach, x.26.71, xi.4.71; Oakwood, x.28.71.

90. *Wallengrenia egeremet* Scudder. Broken Dash

Common and widespread in brushy old fields on a variety of soils; not found in bluestem or switchgrass areas. July ("June-August," Davis), one brood only.

HOST PLANTS: Associated with *Panicum clandestinum*, Willowbrook.

RECORDS: Stapleton, vii.1.71; South Avenue, Arlington to Travis, vii.2.71, vii.12.71, vii.22.71; Tottenville, vii.3.71, vii.14.71, vii.28.71; Sea View, vii.4.71, vii.16.71; Todt Hill, vii.4.71; Buck's Hollow, vii.4.71; Charleston, vii.5.71; Arden Heights, vii.5.71; Willowbrook, vii.16.71, vii.21.71; Midland Beach, vii.20.71. (vii.1-vii.28)

91. *Poanes viator* Edwards. Broad-Winged Skipper

This is the most abundant skipper on Staten Island and in the New York metropolitan area, although it is quite local. Known to Davis only from Dongan Hills, "not uncommon . . . salt meadows." Its food plant locally, reed, now covers vast areas of hydraulic landfills and disturbed tidal marsh and here *Poanes viator* breeds by literal millions where no other butterflies are found. It has colonized patches of reed at all eleva-

tions. Our populations are subspecies *zizaniae* Shapiro, characterized by large size and trimorphic ventral hindwing pattern. One brood, July-August.

HOST PLANTS: Reed (*Phragmites communis*) (ova, larvae, Midland Beach). The host of *P. v. zizaniae* at Philadelphia, Wild Rice (*Zizania*), does not grow on Staten Island.

RECORDS: South Avenue, Chelsea bogs, vii.2.71, vii.12.71, vii.22.71, vii.27.71; Tottenville, vii.5.71, vii.14.71, vii.28.71, viii.18.71; Charleston, vii.5.71; Arden Heights, vii.5.71; Travis, vii.12.71; Mariner's Harbor, vii.15.71, vii.31.71; Graniteville, vii.15.71; Port Ivory, vii.15.71; Willowbrook, vii.16.71, vii.21.71; Sea View, vii.16.71; Midland Beach, vii.20.71; Fox Hills, vii.29.71. (vii.2-viii.18)

92. *Poanes massasoit* Scudder. Mulberry Wing

Local, restricted to the west shore bogs where it is associated with tussock sedge (*Carex stricta*). Frequent, a single brood in July. "Meadows near the foot of New Dorp Lane, August 8, 1885 . . . plentiful near Bull's Head, July 19, 1891." This species was certainly commoner and more widespread in Davis' day; it is still abundant in the Hudson Valley and in the New Jersey Pine Barrens.

HOST PLANTS: Probably *Carex stricta*.

RECORDS: South Avenue bogs, Chelsea and Bloomfield, vii.12.71, vii.22.71, vii.27.71; Woodrow bog, vii.27.71.

93. *Poanes hobomok* Harris. Northern Golden Skipper

"May, June, and July." Probably frequent in open woods at all elevations, but few captures were made in 1971 and none of the dark female. One brood.

HOST PLANTS: Usually associated with *Panicum* spp.; not reared locally.

RECORDS: Stapleton, vii.1.71; Tottenville, vii.14.71.

94. *Poanes zabulon* Boisduval and LeConte. Southern Golden Skipper

Frequent and widespread in brushy old fields, along hedgerows and woods edges, and in rankly overgrown city lots. Two broods, July and mid-August-September ("May, June; August-October," Davis). The territorial males take up perches on sunlit leaves and twigs in woods, 3-10 feet above the ground. Females are more often found in brush and undergrowth. Host plant and early stages unknown on the Island.

RECORDS: Fox Hills, v.24.71; Stapleton, vii.1.71, viii.17.71; Tottenville, vii.3.71, viii.18.71, ix.6.71; Buck's Hollow, vii.4.71; Midland Beach, viii.15.71, ix.8.71, ix.15.71; South Avenue, Chelsea, viii.16.71; Sea View, viii.30.71. (v.24-ix.15)

95. *Atrytone arogos* Boisduval and LeConte. Arogos Skipper

Known only from the serpentine barrens area at the intersection of Bradley and Brielle Avenues, Sea View; there quite common, easily taken on blue vetch, clover, Canada thistle and dogbane flowers. One brood in July. Staten Island is the northernmost record of this little-known insect.

HOST PLANTS: Little bluestem, *Andropogon scoparius*; accepts *A. glomeratus*. Reared from ova deposited by captive females; not surviving on other grasses from the collection site. Constructs a rolled and tied leaf nest. Diapause 2/3 grown.

RECORDS: Sea View, vii.4.71, vii.16.71, vii.21.71 (R. Pine).

96. *Atrytone logan* Edwards. Delaware Skipper

Three localities at Tottenville in brush, frequent; one brood in July.

Not recorded by Davis. At Philadelphia an *Andropogon* feeder, but not found on serpentine here. Visits tall roadside flowers freely; males pugnacious, territorial.

RECORDS: Tottenville, vii.3.71, vii.5.71, vii.14.71.

97. *Euphyes dion* Edwards. Dion Skipper

One of each sex taken on a bog at South near Merrill Avenue. Probably a sedge feeder. In central New York this species usually maintains a very low population density; the males are intensely territorial. Definitely to be considered an "endangered species" on Staten Island.

RECORDS: South Avenue, vii.12.71.

98. *Euphyes conspicua* Edwards. Black Dash

A single specimen—a fresh male—taken on a buttonbush (*Cephalanthus*) blossom with *P. viator* in the same vicinity as the last. This species is usually associated with *P. massasoit* and tussock sedge (*Carex stricta*). Formerly widespread on the Island: "July, August" (Davis).

RECORDS: South Avenue, vii.2.71.

99. *Euphyes bimacula* Grote and Robinson. Two-Spotted Skipper

One female taken with the two *E. dion* on a bog in Bloomfield, 1971. In central New York feeds on stoloniferous sedges, e.g., *Carex trichocarpa* (this species not known on the Island). Common on bogs in the New Jersey Pine Barrens. No old records.

RECORDS: South Avenue, vii.12.71.

100. *Euphyes ruricola metacomet* Harris. Eastern Dun Skipper

Infrequent. Brushy areas and open woods, not seen on acid soils or serpentine. Recorded by Davis for "June, July" and taken in 1971 from July to September, the evidence for a second brood weak although this insect is clearly two-brooded at Philadelphia. Host plants not known locally; presumably grasses.

RECORDS: Tottenville, vii.14.71; Willowbrook, vii.16.71; Wolfe's Pond Park, vii.2.71; Annadale, ix.25.71.

101. *Lerema accius* Abbott and Smith. Clouded Skipper

Infrequent to rare immigrant, taken in weedy sites on flowers on the south shore in autumn; not seen in 1970. Breeds in New Jersey some years on *Paspalum* sp., but not known to breed or overwinter here.

RECORDS: Tottenville, ix.22.71; South Beach, x.8.71.

102. *Atrytonopsis hianna* Scudder. Dusted Skipper

Seen (but not taken) on serpentine-limonite barrens, Fox Hills. Probably frequent in such habitats in June; should be looked for wherever *Hesperia metea* occurs. At Philadelphia, one brood in May, the host plant *Andropogon scoparius*.

RECORDS: Fox Hills, v.24.71.

103. *Nastra therminier* Latreille. Swarthy Skipper

Frequent, to locally abundant on serpentine or sand with the host plant. Open grasslands and brushy situations. Two broods, June-July and August-September; reported by Davis, Tottenville, vi.20.97. There is no reason to doubt that this species overwinters every year on Staten Island.

HOST PLANTS: Little bluestem, *Andropogon scoparius* (ova, Sea View, Travis.)

RECORDS: New Springville, ix.20.70; Stapleton, vii.1.71; Mariner's Harbor, vii.1.71; Huguenot, vii.3.71; Midland Beach, vii.20.71; Tottenville, viii.18.71; Sea View, viii.30.71; Richmondtown, viii.30.71; South Avenue, Travis, ix.1.71.

104. *Panoquina panoquin* Scudder. Salt-Marsh Skipper

Infrequent, restricted to salt meadows on the west shore, where it is seemingly two-brooded (early July, August-September). This species probably suffers from spraying against salt-marsh mosquitoes.

HOST PLANTS: Closely associated with a salt marsh grass, *Distichlis spicata*.

RECORDS: South Avenue, Bloomfield and Chelsea, viii.16.71; Charleston, vii.5.71; Old Place, ix.1.71; Fresh Kills, ix.1.71.

105. *Panoquina ocola* Edwards. Long-Winged Skipper

Irregular immigrant, late in the season on the south shore. Annadale, September 1896 (R. D. Wainwright, reported in Davis). Modern records are from both 1970 and 1971, but there is no evidence of breeding locally. Five were taken at Midland Beach, xi.1.71, but none was in good condition. Visit asters and other late flowers freely.

RECORDS: Wolfe's Pond Park, x.24.70; Midland Beach, xi.1.71.

Species of Uncertain Determination (Pieridae)

106. *Pieris napi oleracea* Harris. Grey-Veined White, Mustard White

Recorded by Davis on the basis of Grote's recollection of taking this species on Staten Island between 1856-1859. *P. n. oleracea*, a Canadian Zone species, occurs in the Catskills and has been reported for the Appalachian highlands of northwestern New Jersey. The similar West Virginia White, *P. virginensis* Edwards, is a Transition Zone species ranging as close to New York City as Westchester County. The host plants of *P. virginensis*, toothworts (*Dentaria*), still reportedly occur on Staten Island but are very local; we have not seen them. No New York metropolitan area specimens that could be referred to either *Pieris* species are known to exist today.

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Many Staten Islanders contributed to the success of this survey. Among Island naturalists, Mr. Harry Betros (Educational Director, High Rock Conservation Center), Mr. Richard Buegler, Miss Mathilde Weingartner and Mr. Howard Cleaves were continual sources of valuable information. Mrs. Gail Schneider and Mrs. Dorothy Kriete made available the extensive library of the Staten Island Institute of Arts and Sciences, and Mr. Joseph Burke did the same for the Davis insect collection. Mr. George Pratt, Director of the Institute, encouraged the project in various ways. Mr. Richard Pine of Great Neck, N.Y. provided and confirmed records. The Richard Buegler and Herman Zaage families were stimulating and tireless hiking companions, and Mr. Zaage took the photographs in figures 10 and 11.

Finally, a special debt is owed the many enthusiastic students at Richmond College who slogged through bogs and clambered over sandhills every Friday afternoon in the name of science.

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Fig. 12. Map of Staten Island localities. (See Appendix I)

APPENDIX I
ALPHABETICAL INDEX OF STATEN ISLAND
LOCALITIES AND HABITATS

Numbers refer to map, figure 12.

1. Annadale. — Arden to Delmar Aves. between Amboy Road and Richmond Parkway. Lowland oak forest on moraine; some boggy ponds.
2. Arden Heights. — Arden Avenue vicinity between Arthur Kill and Woodrow Roads. Lowland oak forest, partly on moraine, partly on sand. Some oak-birch scrub. Includes mowed meadows at Saint Michael's Home.
3. Arlington. — Railroad yard and vicinity west of South Avenue and north of Forest Avenue. Acid sand, with oak-heath scrub and bunchtop bluestem-switchgrass barrens.
4. Bloomfield. — South Avenue from Forest to Travis Aves. Acid barrens, oak scrub, swamp pin oak forest, acid bogs, mostly on gray sand.
5. Buck's Hollow. — vicinity Rockland and Brielle Aves. Upland oak forest, lowland forest, serpentine barrens atop high hills, vernal ponds and a bog. Metropolis of swamp white and basket oaks.
6. Charleston. — Arthur Kill Road and Kreischer Avenue, east to Pleasant Plains. Glacial yellow sands on Cretaceous clays. Oak-birch scrub, a marsh and limited salt marsh areas.
7. Chelsea. — South Ave. and Travis Ave., south to Arthur Kill Road. Acid sand, bogs, lowland scrub, salt marsh, landfill.
8. Clifton. — Urban area, vic. Vanderbilt and Tompkins Avenues. Formerly vacant lot collecting.
9. Eltingville. — Arden to Richmond Aves. between Woodrow Road and Hylan Blvd. Upland and lowland woods, some old fields, terminal moraine.
10. Fort Wadsworth. — Lily Pond Avenue at Seaside Blvd. Rolling lawns open to the south. Late season *Colias*.
11. Fox Hills. — Between Park Hill Apartments and Hylan Blvd., Osgood Ave. to the S.I. Expressway. Serpentine-limonite barrens; terminal moraine; waste ground; ponds.
12. Graniteville. — Diabase quarry on Forest Ave. opposite end of Simonson Ave. Scrub vegetation and marsh. Lowland brush and waste ground spotty south along Richmond Ave. to Jules Drive. Swamp forest in Baron Hirsch Cemetery.
13. Great Kills. — Hylan Blvd. from Emmet to Fairlawn Aves. Beach, goldenrods and asters, hydrofill with reeds.
14. Huguenot. — Hylan Blvd. to Woodrow Rd. between Delmar and Seguine Aves. Lowland oak forest with boggy ponds; birch-sassafras-oak scrub.

15. Latourette Park. — Rockland Avenue near Forest Hill Road. Serpentine uplands with bluestem barrens.
16. Mariner's Harbor. — Morningstar Road to South Ave. from Richmond Terrace to Forest Ave. Urban area with vacant lots, some landfill; acid sand; marshes and railroad tracks.
17. Midland Beach. — Seaside Blvd. between Miller Field and Vulcan St. Beach, thickets, vacant lots, reeds on landfill.
18. New Dorp. — Hylan Blvd. south to the sea, Ebbits St. to Elm Tree Ave. Beach, thickets, vacant lots, landfill.
19. New Springville. — Richmond Ave. near Richmond Hill Road. Extensive landfill and waste ground; salt marsh; upland woods.
20. Oakwood. — Hylan Blvd. to the sea from Ebbits St. to Emmet Ave. Lowland woods, salt creeks, reeds on hydrofill, beach.
21. Old Place. — Waste ground and salt marsh, vic. base of the Goethals Bridge.
22. Pleasant Plains. — Hylan Blvd., Seguine Ave. to Richard Ave. Lowland forest, boggy ponds, acid scrub. Terminal moraine. Damp meadows at Mount Loretto.
23. Port Ivory. — Richmond Terrace near Western Avenue. Extensive vacant lots and waste ground, mainly on landfill.
24. Port Richmond. — Morningstar Road to Jewett Avenue from Richmond Terrace to Forest Ave. Urban area with vacant lots and waste ground.
25. Richmondtown. — Arthur Kill Road at Old Mill Road. Upland serpentine barrens.
26. Richmond Valley. — Drumgoole to Hylan Blvds., Mount Loretto to Page Ave. Acid lowland woods and scrub; boggy ponds.
27. Saint George. — Richmond Terrace and Bay Street to Brighton Avenue and Jersey Street. Urban area with railroad yard, waterfront, vacant lots, some exposures of serpentine.
28. Sea View. — vic. Bradley and Brielle Aves. Upland woods, some scrub, waste ground, old fields, serpentine barrens.
29. Silver Lake. — Forest Avenue at Victory Blvd. Mowed meadows and much-disturbed upland woods.
30. South Beach. — Seaside Blvd. from Lily Pond Ave. to Vulcan St. Beach, vacant lots, reeds on landfill.
31. Stapleton. — vic. Bay Street from waterfront to Ward Hill. Urban area; waterfront; vacant lots; extensive exposure of serpentine vic. Swan and Homer Sts.
32. Todt Hill. — Richmond to Manor Roads between S.I. Expressway and Todt Hill Road. Upland forest, marshes, scrub, serpentine-limonite barrens.
33. Tottenville. — Hylan Blvd. to Arthur Kill Road, south of Page Avenue, Acid scrub, lowland forest, hackberry thickets, beach.

34. Travis. — Travis Ave. from Richmond Ave. to Victory Blvd., south on Victory to end. Acid sand, lowland scrub, marshes and landfill.
35. Watchogue. — vic. Willowbrook Expressway near Lambert's Lane. Lowland forest, formerly extensive acid-sand barrens.
36. West New Brighton. — vic. Broadway from Castleton Ave. to Richmond Terr. Urban area with vacant lots.
37. Willowbrook. — Richmond Avenue near Victory Blvd., east to Willowbrook Road. Swamp forest, boggy areas, old fields.
38. Wolfe's Pond Park. — Hylan Blvd., Cornelia Avenue to Holton Ave. and south to Lemon Creek estuary. Lowland forest, bog, ponds, salt marsh, beach.
39. Woodrow. — Arthur Kill Road to Woodrow Road from Huguenot Ave. to Bloomingdale Road. Deep yellow acid sand with oak scrub, pine barrens relicts, bogs.

APPENDIX II

SOME CLIMATOLOGICAL AND PHENOLOGICAL

ASPECTS OF THE 1971 SEASON

The phenology of any organism represents a profound adaptation to its environment. Natural selection adjusts developmental rates in response to a variety of factors in the physical and biotic environment. The characteristic spring larval period of univoltine oak-feeding Holarctic insects, particularly Lepidoptera, apparently, represents an adaptation to the phenology of tannin production in the leaves of the host (Feeny, 1970). It is noteworthy that the phenology of adult emergence in oak feeders has been dictated by other factors, since early- and late-winter Noctuids and Geometrids, very early spring Hesperids, and midsummer Theclines, to name a few familiar examples, all have spring-feeding larvae. In some cases, phenological adaptations clearly entail the surrender of reproductive potential. The latent polyphenism of *Pieris virginiensis* is a strong argument for its univoltinism being derivative from a multivoltine *napi*-group ancestor; the phenology is closely correlated with that of the host plant, *Dentaria* (Shapiro, 1971a). In most cases butterfly phenology is certainly correlated with climate either directly, or indirectly, through the condition of the host. Among the determinants of phenology and brood sequence, the following may be predicted:

1. Developmental response to weather in a given season must be tightly enough controlled throughout the population to provide for synchronous availability of males and females. Countering this pressure toward standardization of response is the likelihood that absolutely standardized populations would be wiped out in very unusual years, a "group-" or "interdeme" selection argument that would favor the maintenance of some diversity of response. The level of diversity resulting from these conflicting pressures should be determined by the long-term predictability of the environment. Theoretically, the largest potential for genetic diversity of response should be found in populations inhabiting environments with normally high serial correlations but which occasionally produce critically wide deviations from the norm (e.g., late freezes).

2. Generation time and the number of broods per year must be set so as to allow the progeny of the last brood to enter the proper life-history phase (or physiological condition) to survive the adverse season. Since the onset of adverse conditions (e.g., freezes) is variable from year to year, the onset of diapause must be conservative; that is, in many or most years conditions may remain favorable well beyond the time of the onset of diapause, perhaps even permitting an additional generation if part of the population does not diapause. (We have examined the phenology of diapause onset in *Pieris* as related to the variance in the onset of freezing weather at different localities; these data will be presented elsewhere.) If diapause is strictly regulated, then, some reproductive potential is lost in some seasons. In colonizing species with high reproductive rates ("r" species, MacArthur and Wilson, 1967) control of diapause is probably more variable, allowing part of the population to "gamble" against the weather. "Partial" or "false" broods of butterflies probably represent a mixture of such adaptive strategies with developmental accidents. In some cases, the action of natural selection in "standardizing" diapause can be inferred (Shapiro, 1970).

3. The physiological control of diapause onset is normally tied to photoperiod, which is in middle latitudes a much more reliable seasonal predictor than temperature. The breaking of diapause and the control of subsequent development are subject to different pressures since, in addition to predicting the improbability of further adverse weather, they must produce insects synchronously with the availability of host plants. Many diapausing insects require a minimum exposure to low temperatures before resuming development. In general, diapause terminates well in advance of emergence, and the intervening development is temperature-dependent, at least for spring species. Natural selection has probably brought the sensitivities of host plant bud burst and insect emergence into very close agreement; in some cases (e.g., *Erynnis brizo*) the insect emerges prior to host bud burst (*Quercus ilicifolia*, a very late species to leaf out and very subject to frost damage) but does not oviposit until the plant is in suitable condition, but this is exceptional.

4. In general, dates of emergence of multivoltine species and of most univoltine spring species will be earlier as one progresses from cooler to warmer climates, tending to reflect the date of onset of similar weather conditions. Thus *Pieris rapae*

Table 2. Composition of northeastern butterfly faunas by family.

Family	Tinicum- Eastwick	Staten Island	Dist. of Columbia	Central N.Y.	Del. Val.	Va.
Satyridae	4	5	4	5	7	8
Danaidae	1	1	1	1	1	1
Heliconiidae	1	1	-	-	1	1
Nymphalidae	16	22	20	26	26	26
Libytheidae	1	1	1	-	1	1
Riodinidae	-	-	-	-	1	2
Lycaenidae	7	17	13	21	24	20
Liphyridae	-	1	1	1	1	1
Papilionidae	5	6(7)	7	5	6	7
Pieridae	8	8(9)	8	8	9	16
Hesperiidae	30	42	37	38	51	63

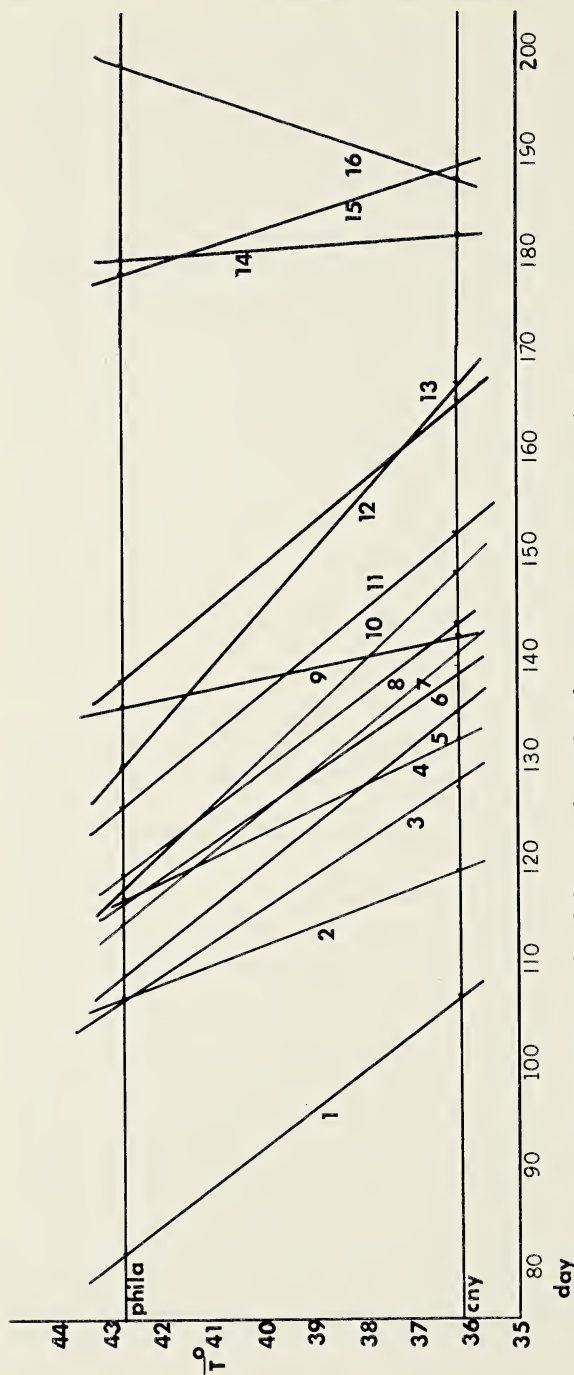


Fig. 13. Postulated linear relationship between mean overwintering temperature and mean first flight for 16 common species, based on Philadelphia and central New York data. Note the high average "sensitivity" of spring species to temperature, as indicated by the gentle slopes. Key: 1. *Pieris rapae*; 2. *Lycaenopsis argiolus*; 3. *Erynnis juvenalis*; 4. *Colias philodice*; 5. *Papilio polyxenes asterius*; 6. *Everes comyntas*; 7. *Colias eurytheme*; 8. *Phyciodes tharos*; 9. *Lycaena phlaeas*; 10. *Papilio glaucus*; 11. *Pholisora catullus*; 12. *Polites peckius*; 13. *Epargyreus clarus*; 14. *Cereyonis alope*; 15. *Satyrus falacer*; 16. *Poanes viator*.

ecloses in late February in the Sacramento Valley of California under a temperature regime substantially identical to that in late March-early April in the northeast, its usual emergence time there. Midsummer univoltines tend to be insensitive to temperature gradients, unlike spring species (Fig. 13). The one widespread non-migratory late summer-autumn univoltine, *Hesperia leonardus*, emerges later southward and downslope, again reflecting the onset of similar weather (mean first dates: central New York, viii.14 (day 227); Philadelphia, ix.8 (day 252)). This tendency was also noted by Clark (1932).

Knowledge of the phenology of animals in general, with the exception of migratory birds, is very poor and this is certainly true of the northeastern butterflies. Since 1958, one of us (AMS) has been gathering phenological data on common, widespread butterfly species in the northeast; such data are now available for Philadelphia, Pennsylvania (1958 through 1966 seasons) and central New York (as defined in Table 1, this paper) (1967 through 1970 seasons) and for the climatically unusual 1971 season at Staten Island, New York. Both the central New York and Philadelphia data embrace wide between-year variances in temperature, precipitation, and per cent sunshine, and while the sampling intervals are not as long as might be desired, they are probably fairly representative. In central New York, the spring of 1967 was much colder than normal and all emergence dates were from one to four weeks later than in 1968-70, which years were closely matched for most species. A detailed treatment of these data will be published elsewhere; the purpose of their introduction here is an attempt to analyze the probable deviation from normal of the 1971 season on Staten Island.

The 1971 Season at New York

Table III shows the 30-year means for maximum, minimum, and monthly temperatures, rainfall, and per cent sunshine at Central Park Observatory, New York City, and the 1971 figures for the same parameters of climate. Many of these values are deceptive because the within-month variance in temperature was higher than normal in both spring and fall, 1971. The general picture, however, is of a cool late winter and spring, an extremely wet summer, and a mild but cloudy autumn. Since only 1971 emergence data are available, is it possible to determine whether these conditions distorted the apparent flight periods of Staten Island butterflies?

Month	Temperature			Precipitation	Pct. of Possible Sunshine	
	Daily Maximum	Daily Minimum	Monthly			
J	39.5 (33.1)	26.9 (20.8)	33.2 (27.0)	3.31 (2.67)	51	(57)
F	40.3 (40.4)	26.4 (29.8)	33.4 (35.1)	2.84 (5.33)	55	(46)
M	47.8 (46.8)	33.2 (33.4)	40.5 (40.1)	4.01 (3.80)	57	(54)
A	59.6 (59.9)	43.1 (41.6)	51.4 (50.8)	3.43 (2.95)	59	(68)
M	71.4 (70.0)	53.4 (52.7)	62.4 (61.4)	3.67 (4.24)	62	(49)
J	80.2 (82.9)	62.5 (65.5)	71.4 (74.2)	3.31 (2.31)	65	(63)
J	85.3 (85.8)	68.2 (69.8)	76.8 (77.8)	3.70 (7.20)	65	(62)
A	83.3 (84.2)	66.8 (67.6)	75.1 (75.9)	4.44 (9.37)	64	(70)
S	76.8 (77.3)	60.1 (65.8)	68.5 (71.6)	3.87 (7.36)	63	(40)
O	66.3 (69.1)	50.3 (56.2)	58.3 (62.7)	3.14 (4.14)	61	(45)
N	53.7 (50.8)	40.3 (39.4)	47.0 (45.1)	3.39 (5.64)	52	(45)
D	42.1 (47.1)	29.7 (34.5)	35.9 (40.8)	3.26 (1.76)	50	(42)

Table III. Normals and 1971 values (in parentheses) for climatic parameters,
Central Park Observatory, New York. (Local Climatological Data,
1971 Annual Summary, U.S. Dept. of Commerce, National Climatic Center.)

An attempt has been made to estimate mean first flights of selected common, widespread species by assuming a linear relationship between mean temperature during the adverse season and mean spring emergence dates. Lines have been drawn for each species using day of the year as the abscissa and mean temperature between October 1 and May 1 as the ordinate, plotting temperature data for central New York and Philadelphia (Table IV) with their corresponding flight dates and noting the date-intercept of the line at New York City mean temperatures (Fig. 13). The results, including predictions of mean first flights at New York, are given in Table V where they are compared to observed 1971 values. It should be clear from the preceding section that these predictions represent extremely crude approximations. (Considerably more reliable estimates may be obtained by analysis of the pattern of onset of warm weather in spring, as noted for *P. rapae* in the previous section.) They do, however, show a definite trend: of 16 species all but 4 emerged later than the predicted date, which would be expected given a cool spring. Field trips to other parts of the northeast confirmed a general lateness of the 1971 season, which reached its extreme in central New York where *Incisalia niphon* was still flying vii.7 and *Satyrrium falacer*, *liparops*, *caryaevorus*, and *acadica* and *Harkenclenus titus* were all still flying viii.22—four and three weeks late, respectively.

The four "early" emergents at New York show no particular life-history attributes in common. *Poanes viator* (and *Cercyonis alope*, which was "late") should probably be discounted since different subspecies are involved, feeding on different hosts (Shapiro, 1971).

The very heavy rainfalls of July through November had little visible effect on flight periods, perhaps because temperatures and levels of cloudiness were not unusual during most of the period. Some carryover may, however, occur in 1972. The most striking impact of the rains seemed to be the abundance of extreme "wet" forms of *Precis coenia* on the inundated south shore. This condition was not observed in the dry 1970 season. The environmental control of pigmentation in *P. coenia* has not been investigated experimentally under well-controlled conditions.

In general, we would predict that mean first flights for most or all spring species on Staten Island should be five to fifteen days earlier than observed in 1971. These estimates are con-

Month	Mean Monthly Temperatures	
	Philadelphia, Pa. ^a	Central New York ^b
J	33.2	26.4
F	33.6	25.7
M	42.3	33.7
A	51.6	45.1
M	63.1	57.3
J	72.1	67.1
J	76.3	71.9
A	74.0	69.8
S	67.7	62.6
O	56.6	52.1
N	45.9	40.3
D	35.9	29.1
Mean Temp., Oct. 1 - May 1 ^c	42.7	36.1

^aClimates of The States, Pennsylvania, 1960, USWB, Dept. of Commerce. Philadelphia International Airport Station.

^bClimates of the States, New York, 1960. Summary for Central Lakes Division.

^cValue for New York City: 41.9.

Table IV. Climatological data used for prediction of flight periods. (See text.)

sistent with the close climatic similarity between Philadelphia and Staten Island.

Number of Broods

The mechanism of switching from one number of generations per year to another is poorly understood and has received very little attention, but it is presumably a threshold phenomenon. The transition may be associated with "partial" broods, a common phenomenon in butterflies perhaps reflecting diversity in the genetic control of diapause. In very few cases are sufficient data available to construct a phenological map for a species and attempt climatic correlations. Two striking cases where this may be possible are the skippers *Polites manataaqua* and *Euphyes ruricola metacomet*, both of which are apparently univoltine on Staten Island but bivoltine at Philadelphia and in southern New Jersey. That the environmental control of flight periods may be quite complex, however, is suggested by the central New York flight data on *P. manataaqua*—which seems partially double-brooded at Ithaca but not in the nearby hills. The impact of phenological isolation of colonies on gene flow among them is a subject needing study. Striking phenological differences have been observed between conspecific populations of several butterflies in the Sacramento Valley and the nearby Vaca foothills, California.

Associated with changes in brood sequence are changes in the biology of overwintering. Species of *Vanessa* and *Nymphalis* overwinter frequently in the pupa at Philadelphia but rarely or never in central New York. Spring flights at Philadelphia consist of a mixture of fresh and worn individuals, but in all the species concerned mating does not occur until spring. Hibernators may, however, mate and oviposit up to three or four weeks earlier than emergents and the amount of gene flow between the two groups is not known. In *Polygonia* spp. mating occurs in the fall (and perhaps again in spring), and no overwintering by pupae is known anywhere.

The seasonal sequence in *Lycaenopsis argiolus*, as discussed under that species, is the most unusual of any of our butterflies. Although genetic factors are clearly implicated in the polymorphism of pattern, pupal diapause seems to be under environmental control at least in part, and the basis for the "skipping" of spring flights at Tinicum (regularly) and Staten Island (1971)

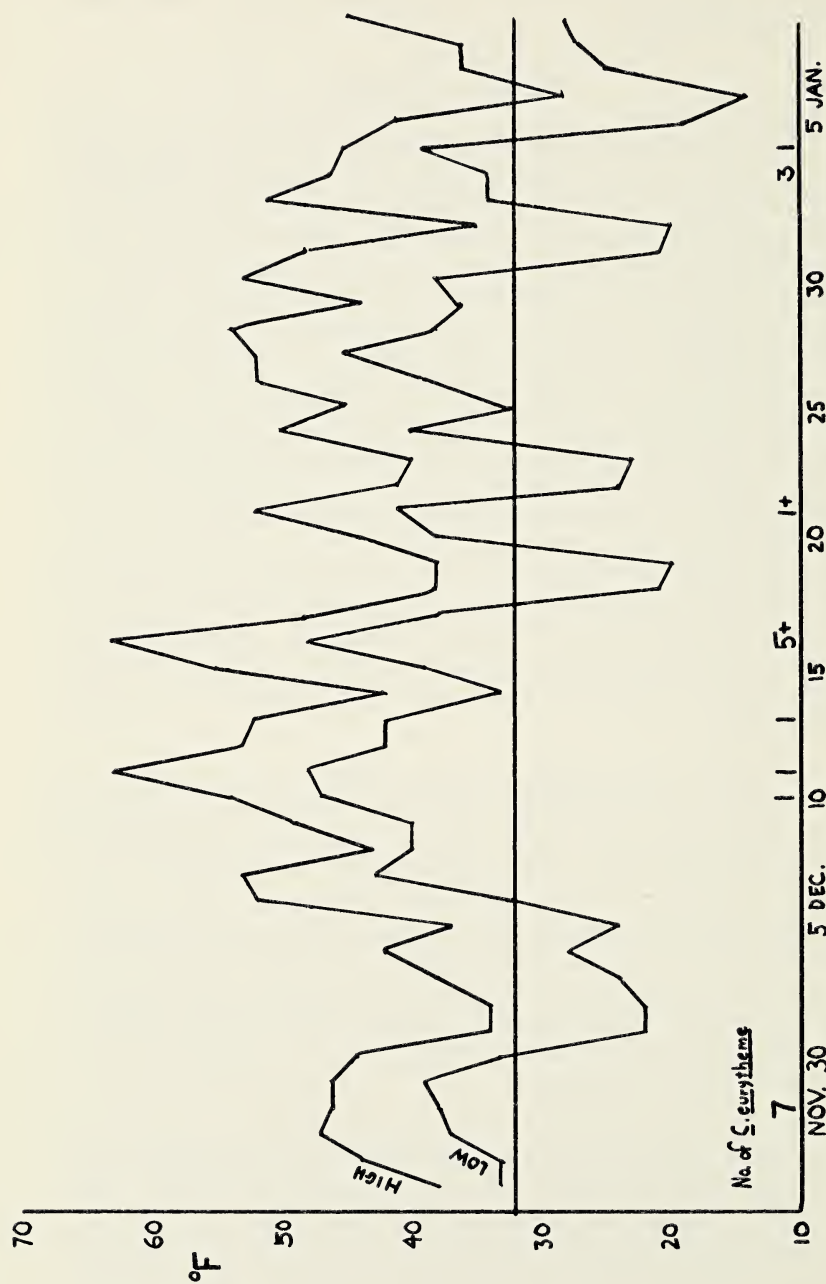


Fig. 14. High and low temperatures and *Colias* collections, early winter 1971-72, Staten Island, N.Y.

	Mean First Dates		Predicted Mean First Date New York City	Observed First Date New York City	Deviation
	Philadelphia, Pa. 1958-1966	Central New York 1967-1970			
<u>Phyciodes tharos</u>	iv.27 (118)	v.22 (143)	iv.30 (121)	iv.21 (112)	(+9)
<u>Satyrus falacer</u>	vi.25 (177)	vi.17 (189)	vi.26 (178)	vi.12 (184)	(-6)
<u>Lycaena phlaeas</u>	v.14 (135)	v.22 (143)	v.15 (136)	v.10 (131)	(+5)
<u>Everes comyntas</u>	iv.25 (116)	v.18 (139)	iv.28 (119)	v.11 (132)	(-13)
<u>Lycaenopsis argiolus</u>	iv.16 (107)	iv.28 (119)	iv.18 (109)	v.14 (135)	(-24)
<u>Colias eurytheme</u>	iv.23 (114)	v.19 (140)	iv.28 (119)	v.5 (126)	(-7)
<u>Colias philodice</u>	iv.25 (116)	v.11 (132)	iv.27 (118)	iv.24 (115)	(+3)
<u>Pieris rapae</u>	iii.21 (81)	iv.16 (107)	iii.26 (86)	iv.11 (102)	(-16)
<u>Papilio polyxenes asterius</u>	iv.18 (109)	v.13 (134)	iv.21 (112)	v.5 (126)	(-14)
<u>Papilio glaucus</u>	iv.26 (117)	v.23 (144)	iv.30 (121)	v.17 (138)	(-17)
<u>Epargyreus clarus</u>	v.8 (129)	vi.16 (168)	v.13 (134)	v.26 (147)	(-13)
<u>Pholisora catullus</u>	v.4 (125)	v.30 (151)	v.7 (128)	v.17 (138)	(-10)
<u>Erynnis juvenalis</u>	iv.16 (107)	v.6 (127)	iv.18 (109)	v.5 (126)	(-17)
<u>Polites peckius</u>	v.17 (138)	vi.14 (166)	v.21 (142)	v.27 (148)	(-6)
<u>Poanes viator ssp.</u>	vi.16 (198)	vi.16 (188)	vi.15 (197)	vi.12 (184)	(+13)
<u>Cercyonis alope ssp.</u>	vi.27 (179)	vi.30 (182)	vi.27 (179)	vi.12 (184)	(-5)

Table V. Mean dates of first flight for selected species at Philadelphia and Central New York; predicted first flights at New York, assuming a linear relation between overwinter temperature and emergence date; and observed first flights at New York in 1971, with deviations from prediction. (See text.)

remains unknown: it is, however, striking that the habitats for the species are so similar in the two areas.

The winter 1971-72 flight of *Colias eurytheme*

The most unusual aspect of the 1971 season was the prolongation of the flight period of the orange sulphur some four weeks beyond normal, into early January at New York and mid-January at Philadelphia. *C. eurytheme* is normally the last non-hibernator on the wing in autumn. Its mean disappearance date averages four weeks after the first frost or roughly after the accumulation of 45 degree-days below freezing (Shapiro, 1962, 69, 70). In 1971-72 these figures were eight weeks and 120 degree-days. The abnormal *sequence* of climatic events probably accounts for these departures. The extraordinary 1971-72 flight can be tentatively ascribed to the following conjunction of events:

1. *Cool, wet, and cloudy weather in November.* The production of a "false brood" in late autumn depends on the timing of the development of mid-autumn immatures. Most of the overwintering at New York is by larvae, and after mid-November conditions are unfavorable for pupation. A reservoir of pupae is generally available in early November; these either eclose as a "false brood" toward the end of the month or early in December if the weather is favorable, or die without eclosing by early winter. November, 1971 averaged 1.9°F below normal and had 5.64 inches of rain, an excess of 2.25, with measurable rainfall on 11 days. We hypothesize that these conditions delayed the pupation of some individuals, and the development and eclosion of pupae already formed, resulting in a larger-than-normal reservoir of pupae available for eclosion later in the season. Pupal mortality due to cold was probably negligible in November since no sub-freezing temperatures occurred.

2. *Failure of cold weather in December.* There were 12 freezes in December, six being in the first week. These represented the first outbreak of arctic air of the season. Data from previous years (Shapiro, 1970) show that conditions of the sort prevailing December 1-6, 1971 do not seriously affect *Colias* populations unless sustained longer. The remaining six freezes were very scattered through the month and there were no days in December on which the temperature remained continuously below freezing; after the sixth, the lowest daily maximum was 38° on

the 18th and 19th, and every other day was above 40°. These minimum-temperature conditions are comparable to November in normal years and do not prevent the subsequent production of a "false brood." The accumulation of a large number of degree-days below 32° was possible in 1971-72 because they were distributed in an autumn, rather than a winter, pattern.

3. *High temperatures in December.* December averaged 4.9° above normal. It was characterized by periods of cloudy, mild weather—conditions suitable for development of pupae, but not flight of adults—followed in each case by one or two sunny and very warm days on which eclosion and flight occurred. Mortality of adults due to cold was probably also low; a worn, fertile female was taken on December 16. This pattern remained intact into mid-January. There were no flight days between December 21 and January 3, but on the latter date fresh individuals were present in numbers at Fort Wadsworth, S.I. The last New York capture was a fresh female taken at rest in overcast early on the morning of January 4 at Port Richmond.

The end of the flight. — Even given the protracted nature of the 1971-72 "false brood," it seems unlikely that the supply of pupae was exhausted before the emergence was halted by cold-induced mortality. On January 6, for the first time in the season, the temperature never exceeded 32°. Warm weather returned January 10 and persisted, with overcast through the 11th yielding to considerable sunshine and very high temperatures on the 12th and 14th. This cloudy-mild becoming sunny-warm pattern had produced flights on each prior occasion. On January 12, we were at Erdenheim, Montgomery Co., Pennsylvania (suburban Philadelphia) and collected 25 *Colias*, all fresh, at the locality mentioned in Shapiro (1969). No *Colias* were seen on January 14 on Staten Island, perhaps because gusty northwesterly winds kept any new emergents down. A cold wave arrived late on January 14 and minima of 10°, 5°, and 10° were set on January 15-17; the mean for January 16 was 10°. No flight has ever been observed after such low temperatures. The mild pattern reasserted itself later in January for several days. We were afield on a potential flight day, January 24, but saw no butterfly activity.

Clark and Clark (1951) record *C. eurytheme* flying January 27, 1947 in Virginia. The last week of January, 1947 set weather records over the entire northeast, with 60's and 70's north to

New England. Unfortunately, no other collections were reported. In 1947, as in 1971, freezes were few and scattered prior to the abnormally warm winter weather. Comparable temperatures with considerable sunshine at Philadelphia in December, 1964 and 1966 and January, 1967 and in central New York in January 1967 failed to elicit *Colias* emergences, but in each case severe cold had preceded the outbreak of warm air.

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NOTICES

WANTED:

Moths of the family Hepialidae in papers or sealed in container with chlorocresol, also larvae and pupae in Bles or similar solution, for distribution study of North American species. Norman E. Tindale, 2314 Harvard Street, Palo Alto, Calif. 94306.

Distributional records and data on habitats and habits for "A biogeographic study of Speyeria diana", by Dr. W.J. Reinthal and J.T. Mithell. Send data to Dr. W.J. Reinthal, 4026 Sequoyah Ave., Knoxville, Tenn. 37919.

Sphingidae of the world. Need particularly Proserpinus vega and P. desepta and Euproserpinus weisti and E. euterpe from the U.S.A. William E. Sieker, 119 Monona Ave., Madison, Wis. 53703.

Exchanges with lepidopterists. B. de los Santos Garcia. Av. Jose Antonio, 349, 2º, Barcelona-4, SPAIN.

Records of Speyeria zerene hippolyta. Edwin M. Perkins, Div. Biol Sci., University of Southern California, University Park, Los Angeles, Calif. 90007.

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BIO QUIP PRODUCTS, catalogue of field, laboratory and storage equipment for the natural sciences. Mailing address: P.O. Box 61, Santa Monica, Calif. 90406. Main office and plant: 316 Washington St., El Segundo, Calif. 90245.

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The Butterflies of the Far East USSR, A. I. Kurentzov (in Russian). Academy of Sciences of the USSR. Siberian Division.

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THE JOURNAL OF RESEARCH ON THE LEPIDOPTERA

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I N T H I S I S S U E

The ecological associations of the butterflies

of Staten Island

Arthur M. Shapiro and

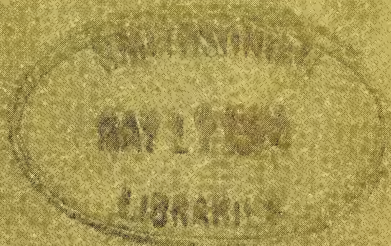
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ON THE ORIGIN OF
AUSTRAL ELEMENTS IN THE MOTH FAUNA
OF SOUTH-EASTERN ONTARIO,
INCLUDING A NUMBER OF SPECIES NEW FOR CANADA

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Queen's University Biological Station, Chaffey's Locks, Ontario

INTRODUCTION

SEVERAL AUTHORS HAVE NOTICED the unique floral and faunal composition of a small area in south-eastern Ontario, consisting of Prince Edward County and the southern portions of Lennox and Addington, Frontenac and Leeds Counties (e.g. Hainault, 1968; Snyder *et al*, 1941; Soper, 1962). Typical austral elements in the ecosystem are much more numerous here than in any other area of Ontario, except the region bordering on Lake Erie.

In recent work concerning the faunal composition of this region we have found a unique abundance of species of Macroheterocera (Hebert, 1969; Harmsen, Hebert and Ward, 1974). Many hitherto considered rare species, some only collected from the Lake Erie region, appear to be relatively common, and a number of species were collected that were new for Canada.

In this communication, we want to record these species as well as two species new for Canada collected on Pelee Island in Lake Erie.

The origin of the austral elements in south-eastern Ontario is a much discussed problem. The composition of the Macroheterocera fauna adds some evidence.

COLLECTING METHODS AND SITES

The south-eastern Ontario records were all collected during a comprehensive complete-season collecting programme conducted at three sites: Glenburnie, Kingston Twp., Frontenac County (5 miles north of Kingston) from 26 April, 1969 to 30 April, 1970; Perth Road, Storrington Twp., Frontenac County

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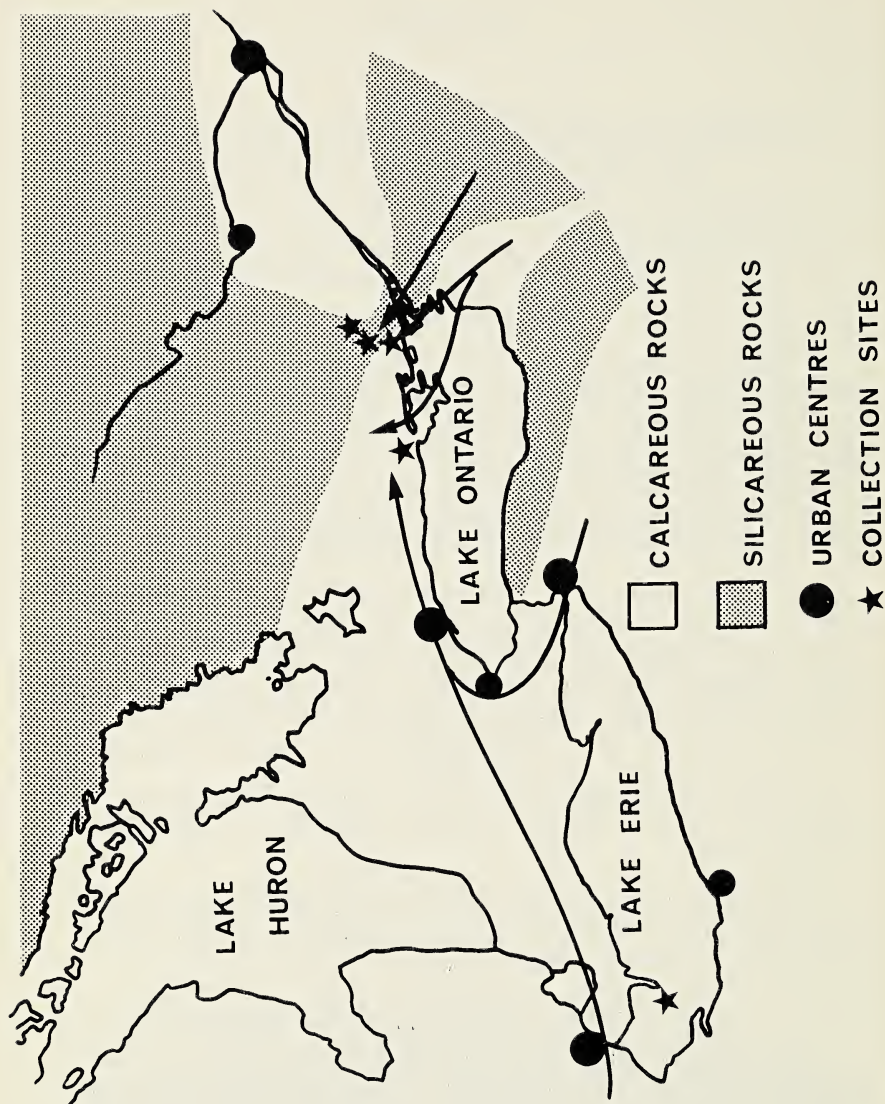


Fig. 1.—Southern Ontario and surrounding regions, showing main geological strata and possible invasion routes for austral elements in the flora and fauna of south-eastern Ontario.

(20 miles northeast of Kingston) from 4 May, 1970 to 26 August, 1970, and from 12 April, 1971 to 1 November, 1971; Queen's University Biological Station, Chaffey's Locks, South Crosby Twp., Leeds County (30 miles northeast of Kingston) from 30 May, 1967 to 7 September, 1967, from 1 May, 1969 to 14 September, 1969, and from 1 May, 1970 to 30 October, 1970, (see Fig. 1). The first site is located in marginal agricultural land on Ordovician limestone. The other two locations are in areas of mixed forest on Precambrian metamorphic rock.

Moths were collected using a 20 watt ultraviolet light (GE F20T12BL) against a white cloth background. The light was run all night and the moths were collected off the sheet at dawn. These regular collections were supplemented by sporadic night collecting in Northumberland County, near Trenton, Ontario in May 1972.

The new species from Pelee Island, Essex County were both collected with an ultraviolet light on a single night's collecting: 6 August, 1969.

NEW CANADIAN RECORDS

We consider a species new for Canada, if it is unrecorded in the literature and if there are no Canadian records in the Canadian National Collection, Ottawa (CNC), the American Museum of Natural History, New York (AMNH), or the Royal Ontario Museum, Toronto (ROM).

1. *Crambidia pura* Barnes & McDunnough. Determined by J. C. E. Riotte.
Glenburnie, 12-26 June, 1969 (5); 6-31 August, 1969 (18).

The American Museum of Natural History contains a series of specimens taken on Picton Island, Clayton, New York, less than two miles from the Canadian border and only about 15 miles from Glenburnie.

2. *Cleora sublunaria* Guenée. Determined by F. H. Rindge.
Perth Road, 19 May, 1971 (1).

A single male of this species was taken on the above date. Its congener, *Cleora projecta* was also taken in May, 1971 at Perth Rd. *C. sublunaria* was not previously known north of latitude 41°N (northern New Jersey, New York City, central Illinois), (Rindge, 1972).

3. *Mellila xanthometata* Walker. Determined by W. C. McGuffin.
Pelee Island, 6 August, 1969 (2).

Although this species is known from the north-eastern states (specimens in CNC, AMNH), the above specimens apparently represent the first Canadian records.

4. *Orthosia alurina* Smith.
Chaffey's Locks, 1 May, 1970 (1).

A single male, whose identity was confirmed by genitalic examination, was collected on the above date. This species is known from New York (Forbes, 1954) and southern Michigan (Nielsen, pers. commun.).

5. *Lacinipolia implicata* McDunnough. Determined by J. G. Franclemont.

Chaffey's Locks, 17 August-7 Sept., 1967 (9); 25 August-1 Sept. 1969 (5); 20 August-7 Sept. 1970 (18); Perth Road, 9-26 August, 1970 (204); 13 August-20 Sept. 1971 (253).

In the CNC there are specimens of *L. implicata* from New Jersey, North Carolina, Tennessee, and Arkansas. It has also been recorded from New York (Forbes, 1954) and Michigan (Moore, 1955). It was found to be surprisingly abundant at the Perth Road locality.

6. *Lithophane querquera* Grote.

Perth Road, 11 May, 1971 (1).

Identification was confirmed by examination of male genitalia. This species is known from the north-eastern states (Forbes, 1954) but not from Michigan (Nielsen, pers. commun.).

7. *Eutolyte electilis* Morrison. Determined by J. G. Franclemont.

Frankford, Northumberland Co. 15 May, 1972 (1). Chaffey's 1-6 May, 1969 (2); 1-10 May, 1970 (3); Glenburnie, 19 May, 1971 (10).

The single specimen from Frankford is typical *electilis*; the remainder are all form *depilis* Grote. This species is known from Ithaca, New York (Leonard, 1928), Pennsylvania (in CNC), and southern Michigan (Moore, 1955).

8. *Oligia chlorostigma* Harvey. Determined by J. G. Franclemont.

Perth Road, 23 July, 1971, (1).

Generally considered a rare species, *O. chlorostigma* is known from New York (Forbes, 1954) and southern Michigan (Moore, 1955).

9. *Neperigea costa* Barnes and Benjamin. Determined by J. G. Franclemont.

Chaffey's Locks, 28 June, 1972 (1); Perth Road, 9-26 July, 1970 (3); 27 June-2 August, 1971 (10).

This species, which is not mentioned by Forbes (1954) or Moore (1955), is primarily a denizen of the American south-west, although it was recently reported from New Jersey (Franclemont, pers. commun.). The above records obviously represent a remarkably disjunct population. In the CNC there is a single specimen of *costa* bearing two labels as follows: "29.VI.18/Gull Lake/Muskoka, Ont." and "Doubt/label/McD." In the light of these recent captures it appears that this old specimen may not have been mislabelled, as was previously supposed.

10. *Bellura melanopyga* Grote. Determined by D. F. Hardwick.

Pelee Island, 6 August, 1969 (1).

The only specimens of *B. melanopyga* in the CNC are from Florida; however, Franclemont (pers. commun.) reports it from farther north including Maine and New York.

11. *Zale phaeocapna* Franclemont. Determined by J. G. Franclemont.

Chaffey's Locks, 1-23 May, 1969 (14); 1-31 May, 1970 (17); Perth Road, 8-30 May, 1970 (5); 7 May-7 June, 1971 (37).

This species is closely similar to *Z. galbanata*. The latter species has also been collected by the present authors, at Glenburnie and at Chaffey's Locks, where it tends to fly somewhat later than *Z. phaeocapna*.

A note of interest is that the Perth Road collecting site is far removed from any hard pine but surrounded by abundant white pine. Thus *phaeocapna* may not be restricted to feeding on hard pines as indicated by Franclemont (pers. commun.). The apparent discontinuous distribution between the present collection and the known range of *phaeocapna* (Forbes, 1954) and the different host plant dependence may suggest that the present collection represents a species close to, but not continuous with *phaeocapna*.

LOCATION OF SPECIMENS

Specimens of the present collections were deposited in the following locations:

<i>Crambidia pura</i>	— CNC, AMNH, ROM, Queen's U.
<i>Cleora sublunaria</i>	— CNC
<i>Mellila xanthometata</i>	— CNC
<i>Orthosia alurina</i>	— CNC
<i>Lacinipolia implicata</i>	— CNC, Queen's U.
<i>Lithophane querquera</i>	— CNC
<i>Eutolype electilis</i>	— CNC, Queen's U.
<i>Oligia chlorostigma</i>	— CNC
<i>Neperigea costa</i>	— CNC, Queen's U.
<i>Bellura melanopyga</i>	— CNC
<i>Zale phaeocapna</i>	— CNC, AMNH, Queen's U.

FAUNAL SIGNIFICANCE OF AUSTRAL ELEMENTS

Four distinct theories are at hand which by themselves or together could explain the unique faunal elements recently observed in south-eastern Ontario.

Firstly, recent drastic changes in the biosphere as a result of human interference in the ecosystem may have considerable effect on faunal integrity and composition. Much of the natural climax forest has been replaced with man-made savannah, and, probably secondarily the climate of north-eastern North America appears to have undergone a warming trend in the past hundred years or so (Thomas, 1957). In these circumstances, not only may marginal species disappear, but new invader species may spread. The latter phenomenon may be expected especially in flying animal species such as moths.

Botanical evidence suggests that the austral elements of the south-eastern Ontario flora are a remnant of the previous climatic high (7-3000 years b.p.) rather than the result of recent invasions (Hainault, 1968). One could expect an associated defoliating animal population to include remnant austral elements as well. Some of the records presented above appear to represent recent colonization resulting from environmental disturbance. For instance *Crambidia pura* may be a recent invasion based on agricultural ecology. Such relatively western species as *Polia segregata* Smith, *Senta defecta* Grote, *Platyperigea meralis* Morrison and *Oncocnemis viriditincta* Smith which have recently been collected in south-eastern Ontario (Harmsen, Hebert and Ward, 1974), supply further evidence for this trend. *Zale phaeocapna* may have expanded its range recently, taking advantage of man's habit of planting red pine in many areas where the tree is not indigenous. There could, however, also be

a link between this species and local populations of red pine and pitch pine in south-eastern Ontario, but equally likely it could represent a remnant population, adapted to different host plants.

The ecological characteristics of other new species however, are not at all suggestive of recent colonization. For example, *Orthosia alurina*, *Lithophane querquera*, *Eutolyte electilis* and *Lacinipolia implicata* are typically associated with deciduous forest habitats in south-eastern Ontario and can hardly be considered spreading northward as a result of a pre-adaptation to man-made aspects of the agricultural ecosystem.

The present records, therefore, seem to reveal, in at least some of the cases, the presence of the anticipated austral fauna, dependent on the typical austral flora of the same region. The origin of this austral refugium in south-eastern Ontario remains a point of debate.

Botanical evidence suggests an invasion of eastern Ontario from New York (see Fig. 1), in a northerly direction across the islands of the upper St. Lawrence River (following acid soils and Precambrian rock, into Ontario Shield country) and eastern Lake Ontario (following alkaline soils and Ordovician limestone via either Wolfe Island or the Jefferson Islands into Prince Edward County) dated at approximately 6000 years b.p.; followed by a general regression during the past 3000 years as a result of a cooling trend in the climate. An invasion in a north-easterly direction from the Lake Erie region along the north shore of Lake Ontario seems far less likely (Hainault, 1968). This latter invasion route, however, finds some support in the distribution of macroheterocera.

Lacinipolia implicata, *Eutolyte electilis*, *Orthosia alurina* and *Oligia chlorostigma* are known from southern Michigan (Moore, 1955; Nielsen, pers. commun.) but not from northern New York State (Leonard, 1928; Forbes, 1954; Franclemont, pers. commun.). Similarly such components of the south-eastern Ontario fauna as *Phoberia atomaris* Hubner, *Chaetagnela cerata* Smith, *Xylomiges alternans* Walker, *Stenoporpia polygrammaria* Packard, *Eupithecia rindgei* McDunnough, *Anisota finlaysoni* Riotte, *Cisthene unifascia* Grote & Robinson, *Poanes viator* Edwards, *Euphyes dion* Edwards, and *Callophrys gryneus* Hubner are western and/or southern species not known from northern New York.

Some of these species have distinct distributions, being apparently absent from the north shore of Lake Ontario between Toronto and Kingston. However this may be partly due to lack

of collecting or disturbance of the original vegetation. Some recent collections made in Northumberland County (approximately 80 miles south-west of Kingston) have disclosed a similar austral fauna (e.g. *Catopyrra coloraria* Fabricius, *Eutolyte rolandi* Grote, *Eutolyte electilis*, and *Phoberia atomaris*).

Some of these species are not associated with an austral flora. Shapiro (1970) presents biogeographical evidence to suggest that *Poanes viator*, *Euphyes dion*, and other marsh butterflies entered the Great Lakes area through the Mohawk Valley in New York at a time (approximately 10,000 b.p.) when the St. Lawrence was blocked by ice and the Ontario basin discharged via the Mohawk Valley to the Hudson and thence the Atlantic. At that time, however, the predominant forest was spruce and fir. Some macroheteroceran species with disjunct distribution patterns may have reached south-eastern Ontario in this fashion but it seems likely that the typical austral elements of the south-eastern Ontario fauna invaded the area much later, during the xerothermic period either northwards from northern New York, or north-westwards from the Lake Erie region.

Since the typical hardwood forest type of the Kingston region appears to cover both limestone formations and Shield country, we feel that the connection between subsoils and migration routes (Fig. 1) has perhaps been overstressed in the past. Certain specialized plants may well be strongly affected by soil types, but the main hardwood species serving as host plants to the majority of phytophagous insects are not.

The meteorological zones of southern Ontario may provide a much more convincing clue to the present distribution of macroheterocera. The tempering effect of Lake Ontario on temperature distribution, humidity, precipitation, snow cover and other climatic factors is probably the main cause of the presence of an area to the north-east of the lake with climatic conditions similar to a narrow strip along the north shore of the lake and the region of the Niagara Peninsula (Phillips and McCulloch, 1972): the prevailing south-west winds in the entire region would easily allow biological dispersal in a north-easterly direction along the north shore of Lake Ontario. North-westerly dispersal from northern New York would be across the prevailing wind, and would have to cross an extensive area directly to the east of the lake endowed with very different climatic conditions (Phillips and McCulloch, 1972).

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THE STUDY OF POPULATIONS OF LEPIDOPTERA BY CAPTURE-RECAPTURE METHODS

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INTRODUCTION

RECENTLY KILDUFF (1973) presented mark-release-recapture data on a population of the butterfly *Euptychia hermes* from which he determined daily population size and a maximum life expectancy. Fosdick (1973) has used identical methods in his study of the butterfly *Anartia amalthaea*. Unfortunately those employed for analysing the population size are inefficient when such extensive multiple recapture data are available, and in addition they violate the assumptions implicit in the underlying mathematical model. Furthermore, the method used for estimating the maximum life expectancy is spurious, since it ignores variation in the number of adults released and the ease with which butterflies were captured from day to day.

Since many people are now using mark-release-recapture methods for studying populations we think it appropriate to mention some of the best available modern methods in order that people can analyse their data efficiently. For the purpose of this paper it would have been convenient to analyse the data of Kilduff and Fosdick but, unfortunately, they are given in such a way that they cannot be analysed by modern methods. Thus, Kilduff tells us that the numbers in the body of his trellis diagram refer to individuals recaptured. However, where a butterfly has been recaptured more than once it is not clear whether the entry in the diamond is appropriate for the first time the insect was captured or the last time, or if recaptured more than twice for some intermediate time. Fosdick declares that in his diagram the numbers also refer to individuals. Nevertheless from Table 1 in his paper it can be seen that the total (189) is greater than the total number of individuals (92). Consequently it seems appropriate not only to suggest efficient methods of analysis but also how the data should be presented in order that the reader may analyse it by modern methods should the author not care to do so.

CAPTURE-RECAPTURE METHODS

Many populations of mobile animals can be investigated using capture-recapture methods. The intuitively easy to understand Lincoln Index (or Petersen estimator) is the simplest and is the basis of more complex mathematical models

$$P = \frac{M_1 N_2}{R_2}$$

where

P is the population estimate on days 1 and/or 2 (see below)

M₁ is the number marked and released into the population on day 1

N₂ is the number captured on day 2

R₂ is the number of recaptures on day 2

When R₂ is large (i.e. over about 20) the estimate of P is fairly unbiased but if there are fewer recaptures Bailey (1951, 1952) has shown that the estimate tends to be too large and is less biased if 1 is added to N₂ and R₂.

$$P = \frac{M_1(N_2+1)}{(R_2+1)}$$

This correction can also be used in the modified Lincoln Index incorporated in multiple recapture models.

The Lincoln Index makes certain assumptions:

- 1) Marking does not affect animals and marks are not lost.
- 2) The marked animals mix randomly in the population.
- 3) The population is sampled at random. An animal's age, sex or mark does not influence its chance of being captured (see later).
- 4) Either there is no birth or immigration (dilution) or there is no death or emigration (loss). If there is no dilution but loss the estimate is valid for the population on the day of release. On the other hand if there is dilution but no death then the estimate is valid for the day of recapture.
- 5) Sampling must be performed at discrete time intervals and the time spent sampling must be negligible (in real terms this means that it must be small) in relation to the inter-sampling period.

Most of the multiple capture-recapture models derived from the Lincoln Index try to remove assumption 4 to make allowance for dilution and loss and they more obviously attempt to represent a *real* animal population. The most popular approaches are listed in Table 1. In general, as one proceeds down this table, one is dealing with methods that need increasing amounts of data (in the form of recaptures). However the models are increasingly realistic and give a more complete series of estimates of parameters of the population. In a capture-recapture study, the type of analysis will depend on the amount of data that can be obtained. Thus where comparatively few recaptures are made Fisher and Ford's method may be the most appropriate, but where more data are available Jolly's, or even Manly & Parr's method may be used.

It is important to realise the limitations imposed by assumption 3 (above). If all individuals are not equally catchable vast errors can occur (see Bishop and Bradley 1973). Any data for analysis must be taken from a population that is as homogeneous as possible. This may demand separate analyses of sub-populations (e.g. The sexes may have to be treated independently.) Any one sub-group may show variability (e.g. polymorphism) that will influence the probability of capture or recapture, so further divisions may be needed. Zoological insight used to assemble data from organisms into homogeneous groups will improve estimates of all parameters obtained from the population models listed in Table 1. If the nature and limitations of a method are understood then it is frequently convenient to use a computer to analyse data. Sources of suitable computer programs are tabulated.

EXAMPLES AND DISCUSSION

Dowdeswell, Fisher and Ford (1940) provide data from a population of the blue butterfly *Polyommatus icarus* on Tean, Isles of Scilly, U.K. These have been presented in such a way that they can be re-analysed to show the sort of estimates that can be obtained from Fisher and Ford's (1947) model (Table 2).

The units in the Fisher and Ford data trellis (Table 2) are marks not animals (it is a Type A trellis in the sense of Leslie and Chitty (1951)). A butterfly caught on 26th August and recaptured on 29th and 30th August contributes one "mark" to 29th August and two "marks" to 30th August. This model also

Table 1

Summary of properties of some popular capture-recapture models. It is essential that animals involved in multiple-recapture studies should be given a date specific mark at every capture or (preferably) an individual mark.

MODEL	No. of samples required	Rate of loss	Rate of gain	Parameters estimated	Best worked example	Computer program	Remarks
Lincoln Index	2	0 Constant 0	0 0 Constant	$P_1 = P_2$ P_1 P_2	-	-	To be used when only two samples are available.
Fisher and Ford (1947)	3 or more	Constant	Variable	(a) P for every sample time except first. (b) single constant survival rate (see remarks). (c) gains and losses.	Re-analysis of data of Dowdswell, Fisher and Ford (1940) by R. J. White. Available on request from J. A. Bishop.	White and Sheppard in Fisher and Sheppard (1973)	Model calculates a single survival rate which is assumed to remain constant for duration of experiment. Requires less data (recaptures) than Jolly's and Manly & Parr's models (Bishop & Sheppard 1973).
Jolly (1965)	3 or more	Variable	Variable	(a) P for every sample time except first and last. (b) survival rate for each inter-sample period except last two. (c) gains and losses.	Jolly (1965) and Southwood (1966)	Davies (1971)	Calculates separate survival rates for inter-sampling periods. These assume that every animal has the same chance of surviving until next sample (i.e. mortality is independent of animals age).
Manly and Parr (1968)	3 or more	Variable	Variable	as by Jolly's model	Manly and Parr (1968)	Calculations simple but program by J. S. Bradley & R. J. White available from J. A. Bishop.	Calculates a separate survival rate for inter-sampling periods. These do not assume that mortality is independent of age.

Table 2

Fisher and Ford type data trellis and estimates of parameters for a population of the blue butterfly Polyommatus icarus on Tean, Isles of Scilly, U.K., 1938. (Data from Dowdeswell, Fisher and Ford 1940) Bailey's correction has been used in the calculation of population estimates.

	Captures	Releases	Aug. 26	27	29	Date of marking Sep.					
						30	31	2	3	6	7
26 Aug. 1938	40	40									
27	43	40	5								
29	13	12	0	3							
30	52	50	3	8	5						
31	56	51	6	12	6	15					
2 Sept.	52	52	4	10	3	16	14				
3	50	50	4	5	1	11	5	14			
6	15	15	1	1	1	3	1	5	5		
7	20	20	1	1	2	3	2	7	8	6	
8	7	0	0	0	0	2	2	4	1	0	4

N.B. The population was not sampled on 28th Aug., 1st, 4th, 5th Sept.

TOTAL DAYS SURVIVED BY MARKS = 788

DAILY SURVIVAL RATE = 0.82831

DATE	MARKS IN POPULATION		POPULATION SIZE		GAINS+	LOSSES+
	NO.	%	RAW	SMOOTH*		
27 Aug	33	13.6	243	204		
28	61			193	25	35
29	50	28.6	176	170	10	33
30	52	32.1	161	148	7	29
31	84	70.2	120	123	1	25
1 Sept	112			108	5	21
2	93	90.6	102	114	25	18
3	120	80.4	149	120	25	20
4	141			112	12	21
5	117			94	2	19
6	97	112.5	86	76	2	16
7	92	147.6	63	65	1	13
8	93	175.0	53	57	4	11

TOTAL GAINS = 116

TOTAL LOSSES = 262

* Third order harmonic running means. + Calculated using smoothed population estimates.

Table 3

Basic capture-recapture data collected from a population of the burnet moth Zygaena filipendulae at Dale, Pembrokeshire, U.K. The complete history of each recaptured individual is shown (capture or recapture indicated by 1) (from Manly & Parr 1968).

[illegible]

Number captured once only
(on day indicated) and not
included above.

21 12 13 9 19

Table 4

Type A and Type B data trellises derived from data in Table 3.

Type A data trellis (for Fisher and Ford's model). Units under 'Date of Marking' refer to marks not animals.

Date	Captured	Released	Date of marking			
			19	20	21	22
19	57	57				
20	52	52	25			
21	52	52	19	20		
22	31	31	9	6	12	
24	54	54	15	12	20	15

Type B data trellis (for Jolly's model). Units record date of last capture of an animal recaptured.

Date	Captured	Released	Date of marking			
			19	20	21	22
19	57	57				
20	52	52	25			
21	52	52	8	20		
22	31	31	2	3	12	
24	54	54	1	6	13	15

Table 5

Estimates of population size and daily survival rate obtained from data of Table 3 by Fisher and Ford's, Jolly's and Manly and Parr's models. (Bailey's correction has not been used)

<u>Date</u>	<u>FISHER & FORD</u>	<u>JOLLY</u>		<u>MANLY AND PARR</u>	
July 1968	Population Size	Pop.Size	Survival rate	Pop. Size	Survival rate
19	-	-	0.78	-	0.76
20	91	93	0.74	90	0.71
21	102	98	0.76	97	0.69
22	116	106	-	93	-
23	-	-	-	-	-
24	75	-	-	-	-
Fisher & Ford survival = 0.801					

The expectation of life is approximately $4\frac{1}{2}$ days. This can be estimated by

$\frac{1}{1 - \text{survival rate}}$ if all deaths occur just before sampling or by $\frac{-1}{\log_e (\text{survival rate})}$ if deaths are at random throughout the intersampling period.

requires a quantity called the total days survived by all marks. On the 29th the mark of the 26th has survived 3 days and on the 30th 4 days. In addition the new mark of the 29th has survived one day. Therefore this animal contributes $3 + 4 + 1$ days to the total. The units in the Jolly data trellis refer to individual animals and the date they were last captured (i.e. it is a Type B trellis). Examples of Types A and B are given in Table 4. The Fisher and Ford method uses the information in the data trellis to calculate a 'survival' rate per unit time for marked animals. This can then be used to allow for loss of marks (by death or emigration) in a modified Lincoln Index calculation. Estimates of population size then can be obtained and gains (birth and immigration) calculated. The complete analysis is given in Table 2. A worked example of Dowdeswell, Fisher and

Ford's data by Mr. R. J. White, Department of Zoology, University of Liverpool, is available from J. A. Bishop. The calculations for Jolly's method are given by Jolly (1965) and Southwood (1966).

Manly and Parr (1968) present a set of results from a capture-recapture investigation of the burnet moth *Zygaena filipendulae*. They also provide a worked example of their model based on this data. Their data are tabulated in a manner that allows re-analysis by Fisher and Ford's and by Jolly's methods. The original data and the Type A and Type B trellises appear in Tables 3 & 4. The estimates of the population parameters provided by all three models are also given (Table 5).

We believe that these examples emphasize the advantages of modern capture-recapture methods. They also indicate the desirability of presenting, where possible, the original data in a simplified but coherent form (Table 3).

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LIFE HISTORY STUDIES OF
IDAEA OBFUSARIA (WALKER)
(GEOMETRIDAE)¹

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ABSTRACT

The ovum, first and final instar, and pupa of *Idaea obfusaria* (Walker) are described, with illustrations and photographs included. Larval habits are discussed and known food plants are given.

INTRODUCTION AND DISCUSSION

THE UNOBTUSIVE GEOMETRID MOTH, *Idaea obfusaria* (Walker) usually is found listed as *Sterrrha punctofimbriata* (Packard) or *Lobocleta obfusaria* form *punctofimbriata* Packard. Evidence presented by D. S. Fletcher (1966) shows that the previously used generic name *Sterrrha* Hübner should be replaced with *Idaea* Treitschke. The correct application of the names *obfusaria* and *punctofimbriata* is presently unresolved.

This species ranges from New Jersey to Florida, west to Arizona. It is widespread, local and rarely common. In Missouri this is a multivoltine species; adults have been taken from mid June through July and again in September. The ova used for this life history study were obtained from a female collected at an ultraviolet light 10 July 1971, near Warsaw, Missouri.

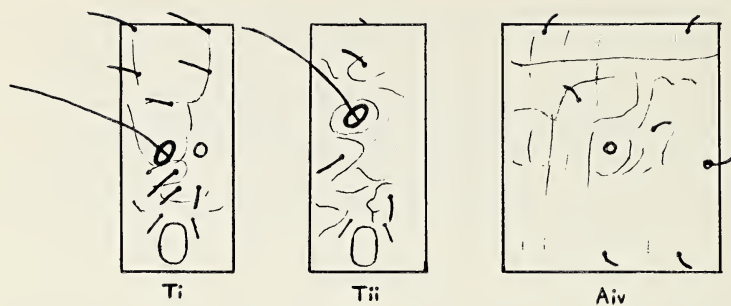
L. obfusaria appears to be generally a low plant feeder eating both fresh and dried leaves. Larvae did equally well on red clover, alfalfa and goldenrod. Walnut, oak and elm were refused, but maple was accepted. Larvae were easily reared on an alfalfa-based artificial diet. Dr. C. V. Covell Jr. has reared Kentucky obtained ova on clover and dandelion.

The larva passes through five instars. The first and final instars are described and illustrated in this article.

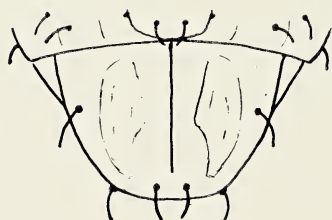
The larva possesses amazing protective adaptations. It resembles a twig, shrivelled leaf or piece of bark in its natural setting. The mottled brown surface of the larva makes a near

¹Contribution No. 246, Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture & Consumer Services, Gainesville, Florida 32601.

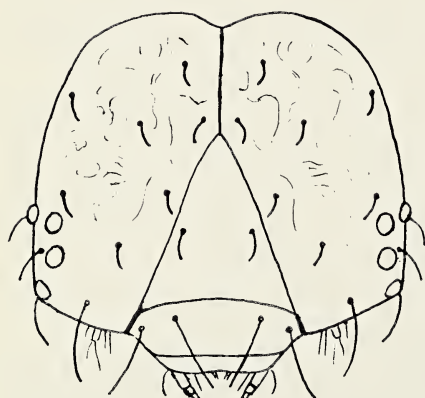
²Research Associate, Florida State Collection of Arthropods, Division of Plant Industry, Florida Department of Agriculture & Consumer Services, Gainesville.



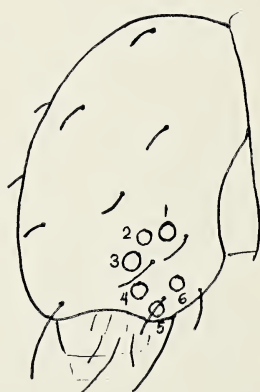
A



B



C



D

Fig. 1.—*Idaea obfusaria* (Walker), A, Setal maps of first instar larva. B, Anal plate of first instar larva. C-D, Head of first instar larva, frontal and left lateral aspect, 150X.

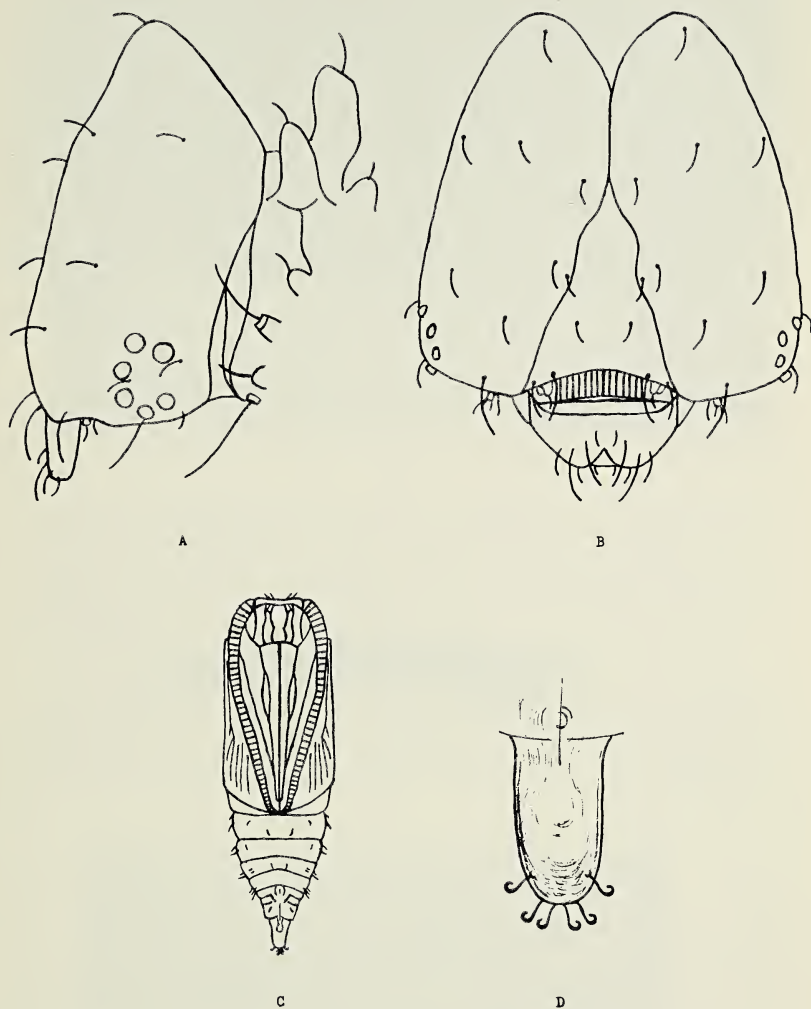
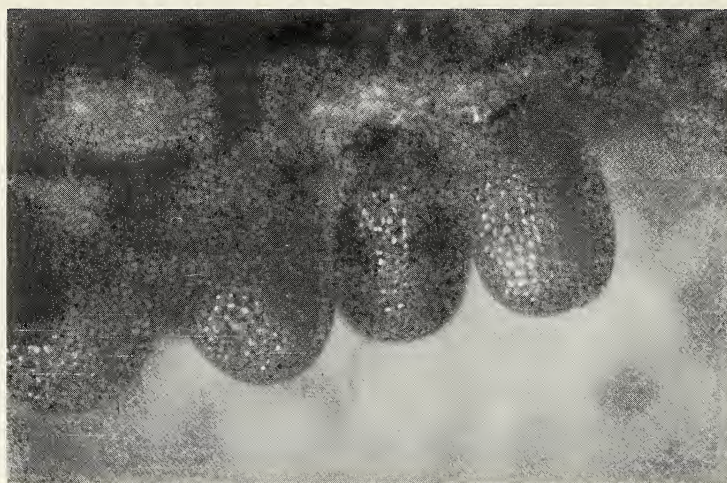


Fig. 2.—*Idaea obfusaria* (Walker), A-B, Head of final instar larva, left lateral and frontal aspect, 44X. C, Pupa, ventral aspect, 5X. D, Cremaster, 30X.



A



B



C

Fig. 3.—*Idaea obfusaria* (Walker), A, Ova, 50X. B-C, Mature larva, lateral and dorsal aspect, 3X.

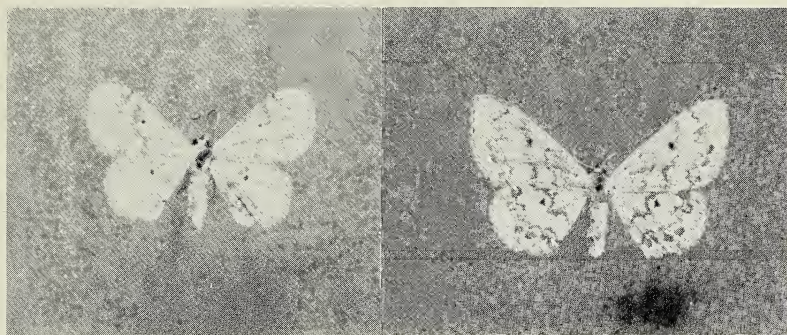


Fig. 4.—*Idaea obfusaria* (Walker), A, Male adult, $1\frac{1}{2}X$. B, Female adult, $1\frac{1}{2}X$.

perfect camouflage. The dorsally flattened and extended segments give it a cobra-like poise. When disturbed the larva becomes rigid and assumes an erect position; when touched the prolegs release, and it falls apparently lifeless. This inert state has lasted as long as 60 minutes. Because of the body shape modifications exhibited by this larva, no typical lateral surface is present. Therefore, in the following description the terms dorsolateral and ventrolateral are used to refer to areas above and below the serrated segmental edge.

DESCRIPTION OF STAGES

OVUM: Height: 0.55mm. Width: 0.40mm. Shape oval, slightly flattened; basal end smaller. Surface with minute indentations of irregular pattern. Color pale yellow with pink undertones. Ova were laid randomly, singly and in small groups. At the basal end of each ovum there is an adhesive stem by which it hangs. Eclosion occurs in four days.

FIRST-STADIUM LARVA: Length: 1.5mm. Width: 0.2mm. Head light orange brown, height: 0.23mm, width: 0.26mm. First thoracic segment white invaded by orange brown; remaining thoracic segments dark brown. Entire ventrolateral surface dark chocolate brown. Dorsolateral surface of abdominal segments dark brown and medium brown with a white W-shaped marking anally directed on each of the first four segments. Center of W not complete on fifth segment; remaining segments brown with cream coloring mixed in.

FINAL-STADIUM LARVA: Length: 16-18mm. Width: 3mm. Head colored in variegated shades of brown sprinkled with darker brown spots; texture rough and pitted; height: 1.3mm, width: 1.1mm. Ocelli 1, 2 and 6 translucent without color; 3,

4 and 5 translucent but dark brown. Dorsal surface flattened and extended with angle from mid dorsum to spiracles slight. Body sharply angled from spiracles to ventral center of abdomen. Dorsal view: body wide, strongly indented at segmental folds; outer edges of segments strongly serrated and bristle tipped; body tapers sharply at thorax and anal end; abdominal segments conspicuously wider than thorax; sixth segment angled down in striking contrast to other abdominal segments; prothoracic segment slightly overlapping the head with four projections topped by a seta and paralleled by a set of four smaller projections behind these. Dorsal surface color variegated in patterns and shades of cream and brown and peppered with darker brown. Ventrolateral surface with irregular bands and patterns of white, gray and browns running the length of the body, darker with more brown than dorsolateral area. Thoracic segments slightly darker than abdominal segments. The meso- and metathorax have a pair of dark brown blotches. Thoracic legs pale brown, cream colored at the base, arrayed with many long brown bristles. Abdominal segments 1-5 have a brown V-shaped marking approximately 1mm in width anally directed. Integument very noticeably wrinkled. Less white on remaining segments. Anal segment with several short spines, and an anal prong 0.35mm in length. Prolegs light brown and cream.

PUPA: Length: 8.5mm. Width: 2.5mm. Pupal surface glossy. Wing cases and first eight abdominal segments pale reddish brown. Intersegmental folds 6, 7 and 8 dark orange brown; final abdominal segments, including the cremaster, red brown. Cremaster with six hooks. Thorax pale orange brown. Head dull light brown. Eyes dark brown. Thoracic spiracles pale reddish brown; abdominal spiracles dark brown. The pupa is suspended in a weak silken netting. Imagines eclose in approximately 14 days.

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SURVEY OF ULTRAVIOLET REFLECTANCE OF NEARCTIC BUTTERFLIES

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THERE HAS BEEN INCREASING interest in the role of ultraviolet in insect-insect and insect-plant interactions. In particular, it has been found that in some butterflies, males use the ultraviolet reflectance of females in intraspecific sexual communication (Obara, 1970). The purpose of this paper is to survey the ultraviolet reflectance of a wide variety of North American butterflies and skippers. This survey will enable future workers to effectively select taxa for detailed experimental studies of the functional utility of ultraviolet reflection. Previous research has been mostly on Pieridae and a few large tropical species of other families, but this study shows that many taxa have "hidden" ultraviolet reflectance patterns just as spectacular and deserving of study. Generalizations about ultraviolet-reflection are made which contribute to knowledge of the relative roles of male and female in the mate-locating process, and of the utility of ultraviolet as an isolating mechanism. This study suggests that a wide variety of behavioral responses to ultraviolet must occur in various taxa because of the great diversity of ultraviolet-reflectance systems.

METHODS

14,000 Papilionoidea and Hesperioidea of about 1000 species from the United States, Canada, and northern Mexico including all species endemic north of Mexico were photographed in full natural noon October sunlight using a Tiffen 18A filter (maximum transmission 360 mμ, 0.1% transmission at 305 and 400 mμ) using a 4 by 5" Speed Graphic camera with a 127-mm Kodak Ektar lens and Polaroid type 52 black and white film (ASA 400), at F11 and 1/50 sec. U-V reflectance was not quantified for the purposes of this survey. Natural variation of ultraviolet is very great (for instance, ultraviolet intensity varies throughout the day, full noon sunlight has twice the intensity of ultraviolet in

June-July as in April and October, and clouds absorb most ultraviolet) so that quantification was not thought to be critical for this brief survey. For detailed studies, spectrophotometry especially, or the techniques of Robert Silberglied (1973, PhD thesis, Harvard University), should be used. The lens and filter used enables ultraviolet only in the approximate range of 350-400 mμ to be recorded on film; therefore some reflectance patterns from 300-350 mμ may have been missed, although the range 300-350 mμ is a minor component of natural ultraviolet, and previous work on one species (Obara, 1970) showed that only the range 380-400 mμ was behaviorally used. A four-letter system was used to describe relative ultraviolet reflectivity: a—weakly reflective, appearing dark in photos; b—moderately reflective, appearing gray in photos; c—quite reflective, appearing light in photos; s—structurally reflective, appearing white in photos (structural reflection did not always appear white). This rough system approximates actual reflectivity, and for detailed studies spectrophotometry is advised. D—dorsal, V—ventral, FW—forewing, HW—hindwing.

RESULTS

A. *Papilionidae* 1) In *Parnassius*, white and yellow mostly absorb ultraviolet, females reflect more than males, and V reflects similar to D. *P. phoebus* is slightly more reflective than *P. clodius*. 2) In *Battus philenor* the white spots of some males and of most females reflect strongly on the HW but rarely on FW; the bluish sheen reflects slightly. In *B. polydamas* the lighter yellowish bands do not reflect. 3) In *Graphium marcellus*, *G. epidaus*, and *G. philolaus*, V reflects more (c) than D (b) light areas. Greenish ground color reflects very slightly, but in *G. epidaus* the wings are uv-transparent. In *G. phaon*, the blue or red spots either absorb, or reflect slightly. 4) In the *Papilio glaucus*-group, V reflects slightly more than D. Postmedian D and V blue spots reflect (s). In *P. glaucus* and *rutulus*, males absorb D, females absorb D or reflect slightly, and both sexes reflect slightly V (b, rarely c). In *P. multicaudata* both sexes absorb D, reflect slightly V. In *P. eurymedon* both sexes reflect D (b), slightly more V. 5) *P. troilus*-group and *P. victorinus*. In some female *troilus*, some female *palamedes*, and some male and female *pilumnus*, the postmedian blue spots are present and reflect (s). VHW median white crescents reflect in at least *troilus* and *pilumnus*. The greenish (in *troilus* and

victorinus) and yellowish spots absorb except occasionally reflect slightly in *pilumnus*. 6) In the *Papilio machaon*-group blue postmedian spots reflect (s). V is more reflective (c) than D. VHW median crescents sometimes reflect as in *P. troilus*. Black forms absorb dorsally. Yellow forms mostly absorb D, with a few males and some females more reflective (a to c). In *P. polyxenes* "*clarki*", *bairdii* "*hollandi*", and a few *P. p. polyxenes*, the D yellow bands of dark forms sometimes reflect (b). In *P. indra*, D bands reflect slightly in ssp. *indra*, *minori* and most *pergamus*, and reflect moderately in ssp. *martini*, *fordi*, and some *pergamus*. 7) In the *Papilio cresphontes* group, V reflect slightly more than D. Postmedian blue spots reflect (s). D yellow bands usually absorb, occasionally reflect (b) especially in females. 8) In *Papilio garamas*, the yellow absorbs dorsally and reflects slightly on the postmedian band VFW (b), but the apical VFW and VHW yellow are highly reflective (c). 9) In *Parides arcas*, the male green spots absorb, and the female white spots reflect only slightly. In *P. arcas* and *P. anchisiades*, the red spots reflect somewhat.

B. *Pieridae* (*Euchloe*). My results on *Pieridae* other than *Euchloe* are not presented because Robert Silberglied is preparing an extensive worldwide survey. 600 individuals of *Euchloe ausonides* were photographed, in connection with prior (Scott 1973) behavioral studies. Small numbers of *Euchloe hyantis* and *E. creusa* were photographed for comparison.

Ultraviolet reflectance of *E. ausonides* was found to vary between D and V, between sexes, between seasons, between individuals, and between localities. 1) *Upperside*. Males are non-reflective; females are almost always slightly reflective. Some females are very reflective, appearing white in the photos. The very yellow dorsal areas on females are usually ultraviolet absorbing; the dorsal hindwings of females are usually yellow and are often more absorbing than DFW. There is poor correlation between the yellow color and uv-absorption, as some very yellow females are very reflective and some white females are relatively non-reflective. 2) *Underside*. The forewing reflects similarly to the D of females. Females have approximately the same reflectivity as males, except that the lightest (most reflective) individuals are females. The female D variation does not occur on V. The green and black ventral spots absorb ultraviolet.

3) *Geographic variation*. California populations (*E. ausonides ausonides*) are variable on the female upperside, but Colorado populations (*E. ausonides coloradensis*) are almost invariant. 32 of 61 females from Point Richmond, Contra Costa County, California, but only 4 of 71 females from throughout Colorado, were highly reflective (white in ultraviolet photos). In all the Colorado individuals the white on VHW was very reflective, but in 11 of 70 males and 18 of 61 females from Point Richmond this white area absorbed ultraviolet and photographed almost as darkly as the green spots. Few individuals of *E. ausonides ausonides* from other areas were photographed, but variation similar to that in California may occur because females from Montana and the Yukon were reflective above, and two females from northwestern Wyoming and Utah absorbed ultraviolet on VHW.

4) *Seasonal variation*. The female dorsal polymorphism is not seasonal, as very reflective females occurred throughout the California flight period from March 3 to June 14. Non-reflective VHW individuals, however, at Point Richmond occurred only after May 16 except for one male caught on April 26 and two intermediate individuals taken in April. *Euchloe* has only one brood, except in central coastal California, where May 16 is the onset of the second mode of emergence (Opler, 1968), and very rarely has a second mode in early July in the Colorado foothills. The second brood apparently represents late emerged individuals, because I found that Point Richmond pupae have obligatory diapause.

5) Several other *Euchloe* species were photographed; they reflect differently than *E. ausonides*. *E. hyantis* shows little variation on the upperside; both sexes are equally reflective and resemble female *E. ausonides* from Colorado (males are more reflective than *E. ausonides* males). *E. hyantis* from Lake Tahoe, California, often have VHW with white areas which absorb ultraviolet. *E. creusa* males are reflective like *E. hyantis* males but females are variable in reflectance, as in *E. ausonides*.

C. Libytheidae. The fulvous color mostly absorbs; white spots reflect.

D. Nymphalidae. The red of *Anaea andria* and *A. aidea* absorbs, but in *A. glycerium* red males reflect moderately while red females reflect slightly. In *A. pithyusa* the blue reflects only slightly. The yellowish of *A. echemus* reflects (b). In *Apatura* and *Limenitis* (includes *Adelpha*), orange spots completely

absorb uv. The DFW of *A. laure* appears mostly black in the photos with a reflecting spot at the anal angle continuing as the DHW reflecting white stripe, whereas in *A. pavon* the wings strongly reflect (s) over most of D, which is purplish black. In female *Apatura*, only the white stripe reflects (c). The V of *A. laure* has a silvery sheen which reflects more than V of *A. pavon*. The white bands of *Limenitis* spp. (and several *Adelpha* spp.) reflect strongly except that those of *L. lorquini* and *L. bredowii* are slightly yellowish and reflect only slightly. The V red of *L. arthemis* absorbs. *L. arthemis astyanax* appears identical in uv and normal photos. *L. archippus* and *Danaus* spp. absorb uv and appear very similar, although Texas (but not Florida) *D. gilippus* reflects slightly more and the wing veins of Texas *D. gilippus* usually reflect uv. In individuals of both sexes of *Myscelia*, and in male *Eunica*, all the wings reflect (s) except the border which is wide in *M. cyananthe*. In uv photos *Biblis* and *Hamadryas* appear identical to visual appearance except *H. ferox* is more reflective dorsally. The red of *Biblis hyperia* reflects structurally, and reflects strongly V. The white of *Mestra* reflects strongly. The red of *Hypanartia* and *Marpesia petreus*, the D brown of *M. chiron*, and the metallic green of male *Dynamine* absorb uv. The V of *Marpesia* reflects (b), and the white V bases of *M. chiron* are highly reflective. The bluish sheen of *Bolboneura sylphis* reflects, (s). The red and fulvous of *Asterocampa*, *Vanessa*, and *Nymphalis* absorbs, and white spots reflect. The FW and HW apical white spots of *N. vau-album* reflect strongly, but the FW apical white spots of other *Nymphalis* are less reflective. The marginal blue spots of *N. antiopa* are highly reflective (s), but the yellow border absorbs. The orange bands of some *N. milberti* reflect slightly basally. In *Precis*, only the anterior DHW eyespot (c), and DFW apical band (a-b) reflect and only in individuals in which these areas are not darkened. The white of *Anartia* reflects (only moderately in some *A. fatima* with slightly yellowish bands) and the fulvous and red absorbs. *Metamorphia* appears similar in uv and normal photos. The fulvous of *Polygonia*, Melitaeini, and Argynnini absorbs, and white spots reflect except that cream-tinged whitish areas (as in *Morpheis ehrenbergi* D and *Chlosyne palla* VHW) reflect only moderately. The lighter fulvous bands of some *Chlosyne theona* and *C. leanira* (some *fulvia*, but no *leanira*, *alma*, or *cyneas*), some *C. palla* females, and some *C. acastus* (especially a light

population from Snake River, Baker County, Oregon) reflect moderately. *Euphydryas phaeton* almost uniformly absorbs, but in other *Euphydryas* in some individuals and populations the light spots reflect somewhat. The silvery V spots of *Boloria*, *Speyeria*, and *Agraulis* reflect (s). The light color of female *Speyeria nokomis* and some female *S. cybele* reflect slightly. The blue or metallic color of *S. diana* females and *S. idalia* does not reflect greatly. In Heliconiini, yellow, orange-fulvous and red areas mostly absorb dorsally, but usually reflect ventrally (slightly in *Colaenis* and *Heliconius isabellae*; (b-c) in *H. charitonius* and *H. erato*). In *Morpho* species, blue structurally reflects ultraviolet but not as strongly as the white of the white species. In Satyrinae, brown, red, and fulvous areas usually absorb ultraviolet. White V markings reflect. Some whitish *Coenonympha tullia californica* individuals reflect moderately. The white of *Euptychia hesione* reflects strongly. *Lethe* females have some slightly reflective lighter areas. The yellow patches of *Cercyonis pegala* sometimes reflect slightly. The white spots of *Gyrocheilus* D reflect.

E. Lycaenidae. 1) Riodininae. White spots reflect. The orange-brown areas of *Apodemia*, *Calephelis*, *Caria*, and *Emesis* absorb uv, as do the yellow and red spots of *Lymnas*, *Baeotis hisbon*, *Argyrogramma sulphurea*, and *Euselasia eubule*. The blue of *Lasaia* and *Anteros carausius* reflects only slightly, but the blue of *Theope virgilius* and *Mesosemia telegone* reflects strongly (s) (including FW postmedian, median, and basal area of *M. telegone*). In *Anteros carausius* the hyaline spots reflect dorsally and ventrally, and the yellowish V basal bar reflects strongly.

2) Theclini. Blue areas are very reflective (s), despite the visual shade (from dark metallic blue of *Ocaria ocrisia* to slightly violet-tinged white of *Thecla meton* males and the violet of *Hypaurotis crysalus*); the following exceptions were noted, which have only weak reflectance: *Panthiades m-album*, *Atlides halesus*, male *Thecla regalis* (in these three species the female reflects more than the male), males of *Thecla phoenissa*, *T. janais*, *T. lyde*, *T. carla*, *T. schausi*, *T. hemon*, and *T. mavors* (D and V, which are metallic green in *mavors*). Reddish brown, brown, and red absorb. Green generally absorbs. White areas of *Thecla meton* females reflect (c). V of many tropical Theclini is highly reflective, and V of most other species is usually more reflective than D. The D green of *Eumaeus deborah* mostly absorbs, the V spots reflect, while the marginal DHW spots (and a blue DFW cell streak of a female)

of *E. atala* reflect fairly strongly. *E. minyas* is intermediate.

3) Lycaenini. Males of some species reflect D, but females are non-reflective. V often lighter than D (usually slightly more, but (c) in *xanthoides* and *heteronea*). The anal angle is non-reflective on male DHW; the non-reflective margin is very narrow in *Lycaena heteronea*, narrow in *L. gorgon*, broader in *L. mariposa* and *L. rubidus*, and broadest in *L. arota*. The following descriptions refer to males unless otherwise indicated. *L. phlaeas* reflects weakly in both sexes. *L. cupreus* (includes *snowi*) males and females reflect more strongly. In *L. mariposa*, *L. gorgon*, *L. rubidus*, and *L. heteronea*, males reflect (s) except for a narrow border and the DHW anal angle. In *L. gorgon*, the whitish DFW spots of one female reflect somewhat. In *L. nivalis*, *L. helloides*, *L. dorcas*, *L. epixanthe*, and *L. thoe*, males reflect (s) except for a narrow border DFW and a broad border DHW, which are non-reflective. In *nivalis*, the D. border is narrower than in the other four species. In *helloides*, whitish females from Yellowstone National Park and southern Montana reflect moderately. In *L. thoe*, the DFW border is narrower, and DFW orange of some females reflects slightly. *L. xanthoides* and *L. editha* are non-reflective. In one *xanthoides* female, submarginal D blue spots reflect. *L. hermes* is non-reflective. *L. pyrrhias*, and *L. arota* reflect all over D wings (s) except a narrow border and the anal DHW angle.

4) Plebejini. Orange mostly absorbs. The blue of males (and females when present) structurally reflects strongly (s). The white of some *Leptotes* and *Celastrina* females reflects strongly. V is usually more reflective than D, and reflects strongly when nearly white as in *Everes* and *Celestrina*. Greenish-metallic color reflects ultraviolet much less (slightly in *Lysandra coridon* from Europe and in *Agriades*; moderately in *Plebejus saepiolus* and in some *P. shasta* populations especially near timberline in Colorado, where some colonies are greenish (moderately reflective) and others are blue (c); (b) in the greenish *P. lupini chlorina*, usually moderately, sometimes strongly reflective in the blue *P. lupini lupini* and *P. l. monticola* (c in *P. acmon*)).

F. HesperIIDae. Fulvous and yellowish colors mostly absorb ultraviolet, with slight differences between species and individuals. White and hyaline spots usually reflect, with some exceptions noted below. In *Megathymus streckeri* and *M. beulahae*, some *M. yuccae* and *Agathymus mariae*, postmedian

fulvous bands reflect slightly. *Atrytone arogos* is slightly more reflective than other Hesperinae species including *A. delaware*. The white of *Heliopetes* absorbs or reflects ultraviolet (a to c); *H. ericetorum* is especially variable. The pure white areas of *Atarnes sallei* absorb, and the white areas of *Onenses hyalophora* and *Polyctor polyctor* reflect only moderately. In contrast, the white areas of *Theagenes albiplaga*, *Chiomara*, and *Mylon lassia* reflect strongly. The white spots of *Pyrgus* and *Xenophanes* absorb, or reflect strongly. The white hyaline spots of *Zestusa dorus* usually absorb but sometimes reflect moderately. The yellowish hyaline spots of *Achalarus lyciades* absorb, while those of *Autochton cellus* reflect slightly. The bluish colors of some *Astraptes*, *Aguna*, *Epargyreus*, and *Urbanus* reflect uv only weakly.

DISCUSSION AND CONCLUSIONS

The following taxa other than Pieridae seem to hold the most promise for experimental studies of the behavioral use of ultraviolet reflectance: *Papilio eurymedon* and relatives, many tropical Nymphalinae, Charaxinae and Morphinae, many tropical Riodininae and Theclini, most Plebejini and *Lycaena*, and some Pyrginae (especially some tropical species).

Tropical species have a greater variety of ultraviolet reflectance patterns than do temperate species, and are more often ultraviolet-reflective.

White and blue, or a metallic sheen over other colors, are usually uv-reflective, and black, brown, fulvous and green usually absorb ultraviolet. The color cannot be used to predict uv-reflectance, however, because of many exceptions; white, yellow, orange, and brown-black, etc., may absorb or greatly reflect ultraviolet in various taxa, and the same color on the same wing may reflect differently dorsally and ventrally (*Papilio garamas*, *Neophasia terlooiti*, etc.). Since there are two means of producing ultraviolet reflection, pigments and structural interference (Ghiradella et al. 1972), this is not surprising.

Males are much more likely to have highly reflective areas than are females. This fact, together with the more common presence of presumed pheromone-producing structures in males, underscores the usual role of the male in making a female receptive for mating, while the female's role is usually in passively deciding whether to allow the male to copulate. Ultraviolet reflection is often similar in closely related species (for instance, *Lycaena rubidus*, *L. heteronea*, and *L. arota* are dissimilar in

color (red, blue, and brown on D of males) but all males are highly uv-reflective). In these taxa the ultraviolet reflectance may be used by the butterfly to distinguish between the sexes, and other stimuli such as pheromones and non-ultraviolet color may be necessary to distinguish between species.

The ground color of females is often slightly more reflective than ground color of males, especially in Pieridae; great sexual dimorphism, as in *P. rapae crucivora* (but not *P. rapae rapae*) may enable males to distinguish between the sexes (Obara, 1970).

The great variety of systems of reflection of male versus female and D versus V casts doubt on a single behavioral explanation of the use of ultraviolet reflection during mating behavior. In Pieridae especially, the behavioral findings of Obara (1970) may not apply to many species (or even to *P. rapae rapae*). In *Neophasia terlooti*, for instance, in which males are white and females red, J. W. MacSwain (oral communication) caught numerous males which came to red plastic cups; the similarity of ultraviolet reflectance of both sexes may mean that the red color rather than an ultraviolet cue is sought by males. In other species, individual variation in reflectivity complicates the situation (*Papilio machaon*-group, *Euchloe*, *Kricogonia*, *Helioptes*, etc.). In some cases, ultraviolet reflection might be used to distinguish between the sexes but not between species (*Phoebis philea* and *Anteos chlorinde* have nearly identical ultraviolet reflectance patterns, as do *Eurema lisa* and *E. nise*, etc.). In other cases, the species may be distinguished using ultraviolet only in one sex, usually the male (some *Eurema*, etc.).

V is usually more reflective than D. D may be darker to absorb more solar energy (mainly non-ultraviolet) during basking, which is usually done by spreading the wings, and ultraviolet absorption is usually correlated with darker color. In some taxa which bask by closing the wings and positioning VHW perpendicular to the sun's rays, such as some Pieridae and Theclini, there is little difference in D and V reflectivity. In *Pieris rapae crucivora*, the difference between D and V in reflectivity may be used to maintain the reflectivity (Obara, 1970); in cool or cloudy weather individuals bask by spreading the wings exposing the more reflective D, and because more ultraviolet is absorbed by the atmosphere when cloudy or when solar radiation passes obliquely through the atmosphere in early morning and late afternoon when cool temperatures are

frequent, the same D reflectivity may be produced as from V at midday or in warm sunny periods.

In some species there is variation of uv-reflectance in which spring individuals are more reflective (*Euchloe ausonides*, *Plebejus acmon* female D). This variation may also make ultraviolet reflectance more similar in spring and summer, because the sun's rays pass through the atmosphere more obliquely in early spring than in summer.

Structurally produced ultraviolet reflection differs from reflection produced by pigments in that the wings may reflect only when viewed at certain angles, which would produce intermittent flashing of ultraviolet by a flying individual. This may serve as an isolating mechanism if the flashing in addition to the static reflectance pattern is utilized by mate-seeking individuals (Crane, 1954).

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BUTTERFLIES OF ST. CROIX

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ST. CROIX IS THE LARGEST of the U.S. Virgin Islands and represents the eastern extremity of the Greater Antilles, 70 miles S.E. of Puerto Rico. The average annual rainfall ranges from 20" in the arid east end to 60" in the high N.W. corner of the island. Vegetation of the dryer areas is predominately cacti-*Croton-Acacia* shrub, while the wetter areas support *Ficus-Cecropia* and other second growth trees. There has been little study of the island's butterflies since Comstock's original *Insects of Porto Rico and the Virgin Islands* (Vol. XII, pt. 4) published by the New York Academy of Science in 1944. This short article will review observations on the status, habitats, and seasonality of the species noted in recent periods of fieldwork (summers 1970-73 and winters 1972-73).

STATUS

Comstock recorded eighteen species, all of which can be found today except for a small Lycaenid (*Leptotes*). I added one species, *Dryas julia*, apparently a wandering accidental. (Specimens are in the author's collection and/or on deposit with the West Indies Laboratory, St. Croix). A species list is presented below with notations of status (for the appropriate season). The limited fauna is typical of small oceanic islands.

DANAIDAE

Danaus plexippus — common.

NYMPHALIDAE

Heliconius charithonius — common.*Dryas julia* — accidental.*Agraulis vanillae* — common.*Precis lavinia* — abundant.*Anartia jatrophae* — uncommon.*Metamorpha stelenes* — common.*Biblis hyperia* — common.*Eunica tatila* — uncommon.*Anaea troglodyta* — uncommon.

LYCAENIDAE

Strymon simaethis — uncommon.*Strymon bubastus* — common.*Leptotes cassius* — extinct?*Hemiargus ceraunus* — common.

PIERIDAE

Phoebis sennae — common.*Eurema daira* — uncommon.*Eurema lisa* — abundant.*Ascia monuste* — abundant.

PAPILIONIDAE

Papilio polydamas — common.

HABITATS AND SEASONALITY

I maintained qualitative descriptions of habitat preferences (open, mixed, or woods) and seasonality. The dry summers provided a direct comparison with the wet winters for the most important seasonal parameter, rainfall. (The significance of wet-and-dry seasonality has been well documented in a variety

of tropical insect groups). Interestingly, there is an apparent interaction between habitat preference and seasonal preference, as shown in Figure 1. Species which are more abundant in the wet season are clearly associated with wooded habitats, while "mixed-open" species are more abundant in the dry season, or show no marked seasonal differences. The biological significance of the habitat-seasonality interaction is probably related to larval food availabilities which could be studied with brief plant surveys. In any case, we note that seasonal patterns of species abundances will vary considerably *between* tropical habitats in a given area.

ACKNOWLEDGMENTS

Dr. John Adams of the West Indies Laboratory kindly shared his own personal notes on the abundance and distribution of the local butterflies. The Laboratory itself provided excellent facilities as a field station.

HABITAT PREFERENCE

	OPEN	MIXED	WOODS
DRY TOLERANT	D.plexippus A.jatrophe A.troglodyta	D.julia	S.simaethis
BOTH WET AND DRY	P.lavinia S.bubastus H.ceraunus E.lisa A.monuste	A.vanillae P.sennae P.polydamas	
WET PREFERENCE		E.daira	H.charitonius M.stelenes B.hyperia E.tatila

Fig. 1.—The seasonality and habitat preference interactions of the eighteen species of butterflies on St. Croix.

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AN IMPROVED METHOD FOR REARING THE MONARCH BUTTERFLY

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FOR SEVERAL YEARS I have been producing Monarch butterflies for migration studies (Urquhart, Urquhart, and Munger 1968 (1970)) and for material in kit form for students and teachers of elementary schools. For these purposes I needed an efficient method of producing quantities of insects which would become butterflies at a predictable time. The method developed is a modification and improvement of a method described previously (Munger and Harriss 1969 (1970)).

I use the milkweed *Asclepias curassavica* to attract egg-laying females and for feeding the larvae in the laboratory because it is perennial and capable of putting out continuous growth in a subtropic climate. Females fed on honey-water in a warm, well-lighted, cloth-covered cage lay eggs on milkweed cuttings. Eggs in lots of 100 or less on pieces of leaves and stems are incubated on pieces of glass under clear, plastic drinking glasses $3\frac{1}{2}$ inches in diameter and 3 inches tall.

The newly-hatched caterpillars are fed tender leaves. When the larvae are in the second or third instar, the drinking glass cages, along with the larvae and the leaves they are feeding on, are transferred to "feeding boards" (Fig. 1).

Feeding boards are smooth, white-enameled pieces of $\frac{3}{4}$ -inch wood $4\frac{1}{2}$ inches wide and about 30 inches long. These boards are supported at each end on pieces of wood shaped to hold one edge $\frac{3}{4}$ inch higher than the other edge, and are spaced about $\frac{1}{2}$ inch apart. When fresh leaves are given to the caterpillars, and the cages need cleaning, the slope of the boards aids in brushing off the debris. The debris is collected on a removable cardboard tray beneath. As the caterpillars eat and grow, they are gradually distributed among other glass cages to prevent over-crowding.



Fig. 1.—Plastic glass cages with Monarch caterpillars on sloping feeding boards.

When the caterpillars reach the fifth instar and are about to begin their heavy feeding they are transferred to special cages. Here they finish their growth and suspend. The special cage (Fig. 2) is a wooden frame 4 inches tall and about 10 inches square covered on 2 sides, on the inside, with window screening and on the bottom with $\frac{1}{4}$ -inch mesh galvanized wire cloth. The top of the cage is covered with a removable sheet of $\frac{1}{8}$ -inch Plexiglas. There is a wooden handle on one side near the top. The cage rests on a painted cardboard tray to prevent the escape of caterpillars.

The under side of the Plexiglas is coated with a very thin layer of paraffin. The paraffin is applied with a soft cloth that has been rubbed on a cake of paraffin. The purpose of the paraffin is to allow easy removal of suspended caterpillars. The cage has a capacity of about 50 caterpillars. The caterpillars in each cage should be of somewhat different ages so that not too many will be spinning mats at the same time.

With the great consumption of food, fecal pellets accumulate rapidly. Cleaning the cage is a simple matter: lift it by the handle, brush the under side of the wire cloth with a stiff paint brush, and set the cage on a clean tray. Rather large amounts of milkweed can be put in the cage at one time, as needed.

When the larvae are full-grown they crawl to the Plexiglas, spin mats and suspend. A sufficiently thin coat of paraffin does not prevent adhesion of the silk; at the same time it allows one to peel off the silk with a larva attached. If there is too much paraffin on the Plexiglas, however, the silk comes off too easily, and the attachment is not strong enough to hold the caterpillar. The silk appears to adhere partly by reason of an electric charge. Ordinary glass is not a satisfactory cover for the cage because the silk cannot be removed easily from it.

The peeling is started with a small, soft-wood stick, such as a broken swab stick, and finished with the fingers. If the larvae are very close together, the matting can be divided with the stick before peeling it off.

After the larvae are removed, they are clipped by their silk to wooden, spring-type clothes pins and set in chronological order, with date-of-suspension labels, on a storage rack (Fig. 3) where they transform and can also emerge. As suspended larvae are removed, they are replaced by transferring young, fifth instar larvae to the cage, thus making the rearing in the special cage continuous.



Fig. 2.—Special cage for growing fifth instar Monarch caterpillars.

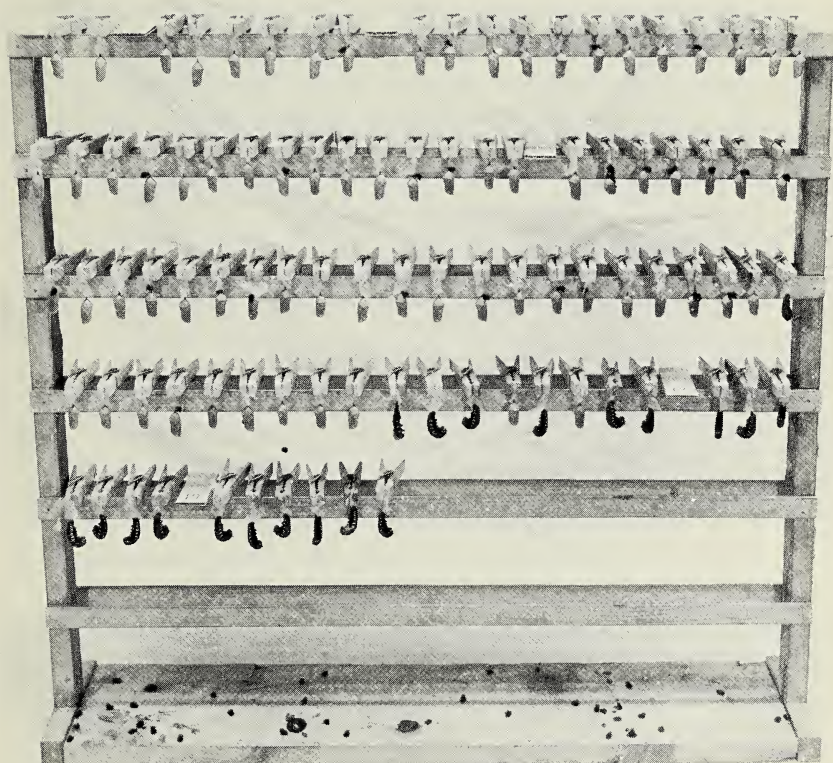


Fig. 3.—Storage rack for Monarch butterfly pupae.

The storage rack is made of 2 upright pieces of wood $\frac{3}{4}$ inch thick and $1\frac{1}{2}$ inches wide fastened to a wooden base $\frac{3}{4}$ inch thick, 6 inches wide, and about 3 feet long. Thin, paired strips of wood are then fastened opposite each other to the edges of the uprights. Several such pairs are fastened to the uprights about 4 inches apart.

After the pupae are 2 days old they are hard enough to be removed from the rack and laid in cotton-cushioned containers. In containers of this type pupae can be placed in a cool or warm place to slow or hasten development, and then returned to the rack to emerge. When properly cushioned, pupae can be shipped safely by mail.

Note: Seeds of *Asclepias curassavica* are available from Harry E. Saier, Dimondale, Michigan 48821.

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Note: Since the above was written, I found that polishing the Plexiglas with automobile wax was as effective as paraffin and easier to apply.

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AN ANNOTATED CHECKLIST OF THE MISSOURI *GEOMETRIDAE* (LEPIDOPTERA)

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ABSTRACT

This is the first state-wide check list of Missouri *Geometridae*. The check list consists of 203 species based on literature records and an examination of over 12,000 specimens.

INTRODUCTION

ONLY ONCE BEFORE HAS a check list of Missouri *Geometridae* been published. This was done by Paul A. Schroers (1914) in part II of his list of moths of St. Louis and vicinity. The list included 60 species of *Geometridae* many of which now seem doubtful. I feel that a state-wide and modern check list of *Geometridae* could be of value to the lepidopterist.

This list is based on the examination of well over 12,000 specimens and all known recorded species. The examined species include the over 1,200 specimens and 119 species of the University of Missouri at Columbia collection, the over 1,200 specimens of other private collections, the 3,600 specimens and 172 species of the J. Richard Heitzman and Roger L. Heitzman collections and over 6,000 donated specimens to museums and universities by the Heitzmans.

The flight period of each species and the counties in which it has been captured are given, over 50 counties are represented. If a species is known solely from literature records it is so noted in the text by reference to the work in which it appears. When a record is dubious it is stated as such. The nomenclature follows McDunnough (1938) and Forbes (1948). Changes from these references are made in accordance with recent revisions.

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FAMILY GEOMETRIDAE

Subfamily Oenochrominae

1. *Alsophila pometaria* (Harris) 24 Sept.-8 Dec.
Green, Pike.
- Subfamily Geometrinae
2. *Nemoria bistriaria* Hübner 5 Apr.-21 Aug.
Benton, Boone, Clay, Franklin, Greene, Jackson, Jasper, Newton,
Randolph, St. Louis, Vernon.
3. *Nemoria mimosaria* (Guenée) 5 May-7 June
St. Louis, Washington.
4. *Nemoria rubrifrontaria* (Packard) May-Aug.
Greene, Ferguson (1969, p. 112), Central Missouri. Packard (1876,
p. 383).
5. *Synchlora aerata* (Fabricius) 21 May-2 Oct.
Benton, Boone, Cape Girardeau, Carter, Clay, Greene, Jackson,
Jasper, Jefferson, Montgomery, Phelps, Pike, Randolph, Ray, St. Clair,
St. Louis, Shannon, Washington.
6. *Synchlora liquoraria* Guenée —dubious—
St. Louis. Schroers (1914, p. 61). Probably in error for *S. aerata*
(Fabricius).
7. *Dichorda iridaria* (Guenée) 15 April-31-Aug.
Benton, Boone, Carter, Clay, Greene, Jackson, Jasper, Newton,
Ozark, St. Clair, St. Louis, Shannon, Taney, Wayne.
8. *Hethemia pistasciaria* (Guenée) 2 May-16 June
Benton, Clay, Jackson, Newton.
9. *Chlorochlamys phyllinaria* (Zeller) 2 May-3 Sept.
Benton, Boone, Callaway, Clay, Howard, Jackson, Jasper, Jefferson,
St. Clair, St. Louis.
10. *Chlorochlamys chloroleucaria* (Guenée) 13 Apr.-9 Sept.
Benton, Boone, Carter, Clay, Franklin, Howard, Howell, Jackson,
Jasper, Jefferson, Newton, Pike, Randolph, St. Clair, St. Louis,
Vernon, Washington.
11. *Chloropteryx tepperaria* (Hulst) 21 Aug.-1 Sept.
Jasper.
- Subfamily Sterrhinae
12. *Euacidalia sericearia* Packard 31 May-3 Sept.
Benton, Clay, Jackson, St. Louis, Washington.
13. *Metasiopsis ossularia* (Geyer) 6 May-14 Oct.
Benton, Boone, Clay, Clinton, Howard, Jackson, Jefferson, Lafay-
ette, Newton, St. Clair, St. Louis, Shannon, Washington.
14. *Metasiopsis perirrorata* (Packard) 20 June-8 Aug.
Benton.
15. *Xystrota rubromarginaria* (Packard) 29 March-21 Aug.
Benton, Boone, Carter, Clay, Cooper, Franklin, Howard, Jackson,
Jasper, Newton, Pike, Randolph, St. Charles, St. Clair, St. Louis,
Shannon.
16. *Scopula aemulata* (Hulst) 14 Apr.-21 Aug.
Benton.
17. *Scopula nigrodisca* Hulst —dubious—Aug.
St. Louis. Forbes (1948, p. 123). This determination is highly
doubtful as the status of this name is very uncertain—see Covell
(1970, p. 193).
18. *Scopula quadrilineata* (Packard) Apr.
Central Missouri. Packard (1876, p. 345).
19. *Scopula limboundata* (Haworth) 21 May-21 Sept.
Benton, Boone, Clay, Franklin, Greene, Jackson, Jasper, Montgom-
ery, Newton, Pike, St. Louis, Shannon, Washington.

20. *Scopula sideraria* (Guenée) —dubious—
St. Louis. Schroers (1914, p. 61 as *Eois sideraria* (Guenée)).
21. *Scopula inductata* (Guenée) 7 May-21 Sept.
Benton, Boone, Camden, Cole, Cooper, Greene, Jackson, Jasper,
Jefferson, Lafayette, Montgomery, Newton, Pike, Randolph, St. Louis,
Vernon.
22. *Scopula plantagenaria* (Hulst) 25 Aug.-26 Aug.
Jackson, Jefferson.
23. *Idaea bonifata* (Hulst)
Greene, Oregon. Fletcher (1966, p. 12) synonymizes *Sterrrha* Hüb-
ner to *Idaea* Treitschke.
24. *Idaea demissaria* (Hübner) 29 May-13 Sept.
Benton, Boone, Clay, Franklin, Howard, Jackson, Jasper, Jefferson,
Newton, Randolph, St. Louis, Shannon, Washington.
25. *Idaea flavescens* (Hulst) 25 May-18 July
Benton, Clay, Franklin, St. Louis, Washington.
26. *Idaea violacearia* (Walker)
Jasper.
27. *Idaea lacteola* (Linter)
Oregon.
28. *Idaea obfusaria* (Walker) 12 June-14 Sept.
Benton, Clay, Randolph, St. Louis.
29. *Idaea miranda* (Hulst) Aug.
Missouri. Forbes (1948, p. 128).
30. *Goniacidalia furciferata* Packard 1 July
St. Louis.
31. *Lophosis labeculata* Hulst
Jasper.
32. *Haematopsis grataria* (Fabricius) 12 Apr.-24 Oct.
Audrain, Benton, Boone, Carroll, Carter, Clay, Clinton, Cooper,
Greene, Henry, Jackson, Jasper, Lafayette, Lincoln, Monroe, Mont-
gomery, Pettis, Pike, Platte, Ralls, Randolph, St. Charles, St. Louis,
Scotland, Vernon.
33. *Calothysanis amaturaria* (Walker) 11 May-24 Sept.
Bates, Benton, Clay, Howard, Jackson, Jasper, Jefferson, Lafayette,
Newton, Pike, Randolph, St. Louis, Shannon, Washington.
34. *Pleuroprucha insulsaria* (Guenée) 14 May-10 Sept.
Benton, Boone, Cape Girardeau, Clay, Cooper, Franklin, Greene,
Howard, Jackson, Jasper, Jefferson, Lafayette, McDonald, Pike, Ran-
dolph, St. Louis, Washington.
35. *Cyclophora packardi* (Prout) 11 Apr.-11 Sept.
Benton, Clay, Jackson, Jasper, Randolph, Shannon, Washington.
36. *Cyclophora pendulinaria* (Guenée)
St. Louis. Schroers (1914, p. 61 as *Cosymbia lumenaria* (Hüb-
ner)).
37. *Cyclophora serrulata* (Packard) 18 May-17 Nov.
Boone, Clay, Jackson.

Subfamily Larentiinae

38. *Nyctobia limitaria* (Walker) —dubious—
St. Louis. Schroers (1914, p. 61 as *N. limitata* (Walker)).
39. *Heterophleps refusata* (Walker) 4 May-5 July
Clay, DeKalb, Jefferson, St. Louis.
40. *Heterophleps triguttaria* Herrich-Schäffer 2 Apr.-1 Sept.
Benton, Boone, Clay, Jackson, Randolph, St. Louis.
41. *Dyspteris abortivaria* Herrich-Schäffer 4 May-28 Aug.
Benton, Carter, Clay, Greene, Jasper, Pike, Randolph, St. Louis.
42. *Trichodezia albovittata* (Guenée) 29 Apr.-8 Sept.
Boone, Clay, Jackson, St. Louis.

43. *Triphosa affirmaria* (Walker)
St. Louis. Schroers (1914, p. 61 as *T. dubitata* (Linnaeus)).
44. *Hydria undulata* Hübner —dubious—
St. Louis. Schroers (1914, p. 61) Probably referable to *H. prunivorata* (Ferguson).
45. *Hydria prunivorata* (Ferguson) 7 May-11 Sept.
Benton, Clay, Franklin, St. Louis.
46. *Coryphista meadi* (Packard) 1 May-18 Sept.
Boone, Jackson.
47. *Eupithecia dichroma-johnstoni* "complex" 14 Apr.-22 Apr.
Benton.
48. *Eupithecia miserulata* Grote 29 March-9 Oct.
Benton, Boone, Clay, Clinton, Cooper, Franklin, Howard, Jackson,
Jefferson, Lafayette, Newton, Randolph, Vernon, Washington.
49. *Eupithecia palpata* Packard 17 Apr.-19 Apr.
Jackson.
50. *Eupithecia herefordaria* Cassino & Swett 17 Apr.-22 Apr.
Benton.
51. *Eupithecia stratonata* Packard 27 May-6 June
Jasper.
52. *Eupithecia indistincta* Taylor 16 Apr.-11 Sept.
Jasper.
53. *Eupithecia fumosa* (Hulst) —dubious—
St. Louis. Schroers (1914, p. 61 as *Tephroclystis absinthia* (Linnaeus)). Because of the early confusion in names in this genus, it is uncertain what this record represents.
54. *Eupithecia swetti* Grossbeck 12 Apr.-19 Apr.
Jackson.
55. *Horisme intestinata* (Guenée) 14 Apr.-7 Sept.
Benton, Clay, Jackson, Jasper, Jefferson, St. Louis.
56. *Lygris diversilineata* (Hübner) 31 May-30 Sept.
Benton, Boone, Clay, Franklin, Jackson, Jefferson, Pike, Putnam,
Randolph, St. Louis.
57. *Lygris gracilineata* Guenée 21 May-4 Oct.
Benton, Boone, Clay, Clinton, Franklin, Jackson, Newton, Pike,
St. Louis, Washington.
58. *Diactinia atrocolorata* (Grote & Robinson) 26 June-15 July
St. Louis.
59. *Dysstroma truncata* (Hufnagel) —dubious—
Missouri. Packard (1876, p. 107).
60. *Hydriomena pluvialata meridianata* McDunnough 2 Apr.-7 May
Benton, Jackson.
61. *Hydriomena transfigurata* Swett 17 Apr.-7 May
Benton.
62. *Hydriomena renunciata* (Walker) —dubious—
Missouri. Packard (1876, p. 93 as *H. trifasciata* Packard).
63. *Hydriomena californiata* Packard —dubious—
Central Missouri. Packard (1876, p. 95) Probably in error for *H. bistrilata* (Zeller).
64. *Hydriomena bistrilata* (Zeller) 8 Apr.-7 May
Benton, St. Louis.
65. *Hydriomena mississippiensis* McDunnough 8 Apr.-14 May
Benton, Boone, Jackson, Jasper, Vernon.
66. *Xanthorhoe lacustrata* (Guenée) 22 March-7 Sept.
Barton, Benton, Carter, Clay, Franklin, Jackson, Jasper, Randolph,
St. Louis.

67. *Nycterosea obstipata* (Fabricius) 6 Feb.-11 Nov.
Benton, Boone, Clay, Clinton, Cooper, Franklin, Jackson, Jasper,
Jefferson, Montgomery, Newton, Pike, Randolph, St. Louis, Taney,
Vernon, Washington.
68. *Euphyia centrostrigaria* (Wollaston) 15 Apr.-8 Sept.
Benton, Boone, Carter, Clay, Franklin, Jackson, Jasper, Jefferson,
Newton, Randolph, St. Louis, Washington.
69. *Euphyia multiferata* (Walker) 8 Apr.-7 May
Benton, Jackson.
70. *Camptolina stellata* (Guenée) 21 Aug.-12 Nov.
Benton, Boone, Clay, Howard, Jackson, St. Louis.
71. *Rheumaptera hastata* (Linnaeus) 1 June-25 June
Pike, St. Louis.
72. *Venusia comptaria* Walker Apr.
Jasper.
73. *Hydrelia albifera* (Walker) 29 May-30 Aug.
Benton, Franklin, Jasper, Randolph, St. Louis, Shannon, Washing-
ton.
74. *Eubaphe mendica* (Walker) 10 May-2 Sept.
Benton, Boone, Clay, Franklin, Greene, Henry, Jackson, Jasper,
Jefferson, Newton, Pike, Reynolds, St. Louis, Shannon, Vernon,
Washington.
75. *Eubaphe unicolor* (Robinson) 14 Apr.-20 June
Benton, Jackson, Jasper.
Subfamily Ennominae
76. *Bapta vestaliata* (Guenée) 9 Apr.-12 Aug.
Benton, Boone, Clay, Franklin, Howard, Jackson, Jasper, Jefferson,
Montgomery, Newton, Pike, Randolph, St. Louis.
77. *Bapta glomeraria* (Grote) 7 Apr.-29 Apr.
Benton, Boone.
78. *Cabera quadrifasciaria* (Packard) 1 May-1 June
Benton, St. Louis. Fletcher (1966, p. 12) synonymizes *Deilinia*
Hübner to *Cabera Treitschke*.
79. *Apodrepanulatrix liberaria* (Walker) 7 Sept.-20 Oct.
Boone, Camden, Jasper, St. Louis.
80. *Syrphodia coloraria* (Fabricius) 24 May-15 July
Benton, Carter, Greene, Jackson, St. Louis.
81. *Syrphodia cruentaria* (Hübner)
Oregon.
82. *Narraga fimetaria* (Grote & Robinson) 4 Apr.-30 Aug.
Benton, Jackson, Jasper.
83. *Itame inextricata* (Walker) —dubious—
St. Louis. Schroers (1914, p. 61 as *Mellila inextricata* (Walker)).
84. *Itame pustularia* (Guenée) 23 May-23 July
Benton, Clay, Franklin, Jackson, Jasper, Jefferson, Newton, Pike,
St. Louis, Scotland.
85. *Itame abruptata* (Walker) 6 June-7 June
Franklin, Washington.
86. *Itame ribearia* (Fitch) 4 June-21 June
DeKalb, Franklin, Jasper, Jefferson, Newton, St. Louis.
87. *Itame flavicaria* (Packard) 17 May-25 May
Clay, Jackson.
88. *Itame coortaria enigmata* Barnes & McDunnough 27 May-21 July
Boone, Franklin, Jackson, Jasper, Pike.
89. *Mellilla xanthometata* (Walker) 6 Apr.-1 Nov.
Benton, Boone, Carter, Clay, Franklin, Greene, Howard, Jackson,
Jasper, Jefferson, Johnson, Newton, Pike, Randolph, St. Louis, Wash-
ington.

90. *Heliomata cycladata* Grote 5 June
Franklin, Jasper, Oregon.
91. *Semiothisa ulsterata* (Pearsall) 5 May-31 Aug.
Benton, Boone, Clay, Franklin, Howard, Jackson, Jasper, Jefferson,
Randolph, St. Louis, Shannon, Vernon, Washington.
92. *Semiothisa aemulataria* (Walker) 30 March-26 Sept.
Benton, Boone, Cape Girardeau, Clay, Franklin, Howard, Jackson,
Jasper, Jefferson, Newton, Pike, Randolph, St. Louis, Washington.
93. *Semiothisa bicolorata* (Fabricius) 5 June-20 Sept.
Franklin, Randolph, St. Louis, Shannon.
94. *Semiothisa transitaria* (Walker) 27 June
Jackson.
95. *Semiothisa multilineata* (Packard) 8 Apr.-31 Aug.
Benton, Franklin, Gasconade, Howard, Jackson, Jasper, St. Clair,
Washington.
96. *Semiothisa punctolineata* (Packard) 16 Aug.-13 Oct.
Clay, Clinton, Jackson, Lafayette, St. Louis.
97. *Semiothisa quadrinotaria* (Herrich-Schäffer) 14 Apr.-7 July
Benton, Boone, Clay, Jackson, Jefferson, Pike, St. Louis, Washing-
ton.
98. *Semiothisa colorata* (Grote) 7 May
Benton.
99. *Semiothisa maculifascia* (Hulst) 7 May-29 Aug.
Benton, Carter, Clay, Franklin, Randolph, St. Clair, St. Louis,
Washington.
100. *Semiothisa delectata* (Hulst) 14 Apr.-27 Aug.
Benton, Clay.
101. *Semiothisa orillata* (Walker) 29 March-16 Sept.
Benton, Boone, Camden, Clay, Jackson, Jefferson, St. Clair, St.
Louis, Shannon.
102. *Semiothisa nigrocomina* (Warren) 31 July
Jackson, St. Louis.
103. *Semiothisa ocellinata* (Guenée) 6 Feb.-10 Oct.
Benton, Boone, Clay, Howard, Jackson, Jasper, Jefferson, Pike,
Randolph, St. Louis, Vernon.
104. *Semiothisa mellistrigata* (Grote) —dubious—
St. Louis. Schroers (1914, p. 61 as *Sciagrapha mellistrigata* Grote).
Probably in error for *S. subminiata* (Packard).
105. *Semiothisa subminiata* (Packard) 20 Apr.-9 Sept.
Benton, Boone, Clay, Jackson, Jefferson, St. Louis.
106. *Semiothisa snoviata* (Packard)
Missouri. Forbes (1948, p. 48). *Snoviata* is now generally con-
sidered a color form of *S. subminiata* (Packard).
107. *Semiothisa gnophosaria* (Guenée) 7 Apr.-31 Aug.
Benton, Boone, Clay, Cooper, Howard, Jackson, Jefferson, Pike,
St. Louis, Vernon, Washington.
108. *Semiothisa cyda* (Druce) 29 July-20 Aug.
Benton, Jackson.
109. *Semiothisa tenebrosata* (Hulst) —dubious—
St. Louis. Schroers (1914, p. 61 as *Cymatophora tenebrosata*
(Hulst)).
110. *Enconista dislocaria* (Packard) 8 Apr.-31 Aug.
Benton, Boone, Clay, Jackson, Jasper, Newton, St. Clair.
111. *Eumacaria latiferrugata* (Walker) 8 Apr.-2 Sept.
Benton, Boone, Clay, Franklin, Howard, Jackson, Newton, Ran-
dolph, St. Louis, Washington.
112. *Protitame virginalis* (Hulst) 7 May-29 Aug.
Benton, Clay, Jackson, Jefferson, Montgomery, Randolph, St. Clair,
Washington.

113. *Elpiste lorquinaria* (Guenée) —dubious—
St. Louis. Schroers (1914, p. 61 as *Sympherta tripunctaria* (Packard)).
114. *Ematurga atomaria amitaria* (Guenée)
St. Louis. Riley (1890-1, p. 151); Missouri. Packard (1876, p. 233).
115. *Eufidonia notataria* (Walker)
St. Louis. Schroers (1914, p. 61).
116. *Hypagyrtis subatomaria* (Wood) 14 Apr.-7 Sept.
Benton, Boone, Clay, Clinton, Franklin, Howard, Jackson, Jasper, Jefferson, Newton, Pike, Platte, Randolph, St. Clair, St. Louis, Vernon, Washington.
117. *Hypagyrtis esther* Barnes 5 June-7 June
Franklin.
118. *Hypagyrtis* (undescribed species) 5 June-7 June
St. Louis, Washington.
119. *Tornos scolopacinarius* (Guenée) 17 March-4 Oct.
Benton, Boone, Clay, Clinton, Cooper, Greene, Henry, Howard, Jackson, Jasper, Jefferson, McDonald, Monroe, Pike, Randolph, St. Louis, Saline, Vernon.
120. *Exelis dicolus* Rindge 14 Apr.-31 Aug.
Benton, Clay, Franklin, Howard, Jackson, Jasper, Newton, Washington.
121. *Melanolophia canadaria crama* Rindge 29 March-29 Aug.
Benton, Clay, Franklin, Howard, Jackson, St. Louis, Shannon.
122. *Melanolophia signataria* (Walker) 29 March-4 May
Benton, Boone, Clay, Jackson, St. Louis.
123. *Protoboarmia porcelaria* (Guenée) 17 May-6 June
Franklin, Jasper, Oregon, St. Louis, Washington.
124. *Cleora sublunaria* (Guenée) 6 Apr.-29 May
Benton, Clay, Jackson, Jasper.
125. *Pseudoboarmia umbrosaria* (Hübner) 8 Apr.-29 July
Benton, Newton, Vernon.
126. *Pseudoboarmia gnopharia* (Guenée) 8 Apr.-20 Aug.
Benton.
127. *Glena cribrataria* (Guenée) 3 May-5 Aug.
Benton, Franklin.
128. *Glena plumosaria* (Packard) 6 June
Washington.
129. *Stenoporpia polygrammaria* (Packard) 23 Apr.-20 Aug.
Benton, Pike, Randolph, St. Louis, St. Clair.
130. *Anavitrinella pampinaria* (Guenée) 4 Apr.-4 Oct.
Benton, Boone, Camden, Cape Girardeau, Cass, Clinton, Franklin, Howard, Jackson, Jasper, Jefferson, McDonald, Newton, Pike, Platte, Randolph, St. Clair, St. Louis, Shannon, Washington.
131. *Anacamptodes defectaria* (Guenée) 8 Apr.-2 Nov.
Benton, Boone, Butler, Clay, Clinton, Franklin, Howard, Jackson, Newton, Randolph, St. Louis, Shannon, Ste. Genevieve, Washington.
132. *Anacamptodes ephyraria* (Walker) 16 Apr.-27 July
Jefferson, Pike, St. Louis.
133. *Anacamptodes humaria humaria* (Guenée) 29 March-3 Sept.
Benton, Boone, Clay, Clinton, Franklin, Jackson, Jefferson, Pike, Randolph, St. Louis, Washington.
134. *Anacamptodes vellivolata* (Hulst) 10 Apr.-11 July
St. Louis.
135. *Nepterotaea* (undescribed species) 20 Apr.-25 Aug.
Benton.
136. *Ectropis crepuscularia* (Schifferrmüller) 3 Apr.-26 Sept.
Benton, Boone, Clay, Clinton, Franklin, Howard, Jackson, Jasper, Jefferson, Newton, Pike, Randolph, Reynolds, St. Louis, Washington.

137. *Glenoides texanaria* (Hulst) 28 June-4 Oct.
Benton, Clay, Clinton, Franklin, Jackson, Newton, Randolph,
Washington.
138. *Pimaphera sparsaria* (Walker) 16 June-29 Aug.
Benton, Camden, Newton.
139. *Epimecis hortaria* (Fabricius) 21 Apr.-5 Sept.
Clay, Greene, Jasper, Jefferson, Newton, Pike, St. Louis.
140. *Lycia ypsilon* (Forbes) 29 March-4 May
Benton, Boone, Clay, Jackson.
141. *Lycia ursaria* (Walker) 31 March-16 Apr.
Clay, St. Louis.
142. *Biston cognataria* (Guenée) 28 Apr.-20 Aug.
Benton, Boone, Clay, Clinton, Jefferson, Pike, Randolph, St. Louis.
143. *Phaeoura quernaria* (J. E. Smith) 8 Apr.-18 May
Benton, Boone, Clay, St. Clair.
144. *Phigalia olivacearia* (Morrison) 19 March-28 March
Boone, Jackson, St. Louis.
145. *Phigalia denticulata* Hulst 18 Jan.-12 Apr.
Boone, Jackson, St. Louis.
146. *Phigalia titea* (Cramer) 21 March-8 Apr.
Benton, Jackson.
147. *Paleacrita vernata* (Packard) 14 Jan.-15 May
Boone, Greene, Jackson, Johnson, St. Louis, Vernon.
148. *Paleacrita merriccata* Dyar 26 March
St. Louis.
149. *Erannis tiliaria* (Harris) 3 Nov.-14 Nov.
Boone, Jackson, Oregon, St. Louis.
150. *Lytrosis permagnaria* (Packard)
Missouri. The holotype collected by C. V. Riley in the last century
is the only known Missouri specimen.
151. *Lytrosis heitzmanorum* Rindge 28 May-6 June
Benton, Franklin.
152. *Lytrosis sinuosa* Rindge 5 June-7 June
Franklin, St. Louis, Washington.
153. *Lytrosis unitaria* (Herrich-Schäffer) 25 May-7 July
Benton, Boone, Camden, DeKalb, Franklin, Jackson, Jasper, La-
fayette, Pike, Platte, St. Louis, Washington.
154. *Eugonobapta nivosaria* (Guenée) 10 June-27 July
Boone, Jefferson, Pike, St. Louis.
155. *Euchlaena serrata* (Drury) 5 June-1 Aug.
Benton, Boone, Greene, Jasper, Moniteau, Newton, Pike, Randolph,
Scotland, Vernon.
156. *Euchlaena obtusaria* (Hübner) 18 May-7 Sept.
Bates, Benton, Clay, Jackson, Jasper, Jefferson, Newton, Pike, Ran-
dolph, St. Louis, Shannon, Washington.
157. *Euchlaena effecta* (Walker)
St. Louis. Schroers (1914, p. 62).
158. *Euchlaena johnsonaria* Fitch 26 May-15 Sept.
Benton, Boone, Clay, Greene, Jackson, Jasper, Jefferson, Lafayette,
Newton, Pike, Randolph, St. Louis.
159. *Euchlaena amoenaria* (Guenée) 26 May-5 Aug.
Benton, Clay, Jasper, Randolph, St. Louis.
160. *Euchlaena madusaria* (Walker) 15 May-21 Aug.
Benton, Clay, Greene, Randolph.
161. *Euchlaena marginaria* (Minot) 9 Apr.-29 May
Benton, Cass, Clay, Jackson, Jefferson, Johnson, Platte.
162. *Euchlaena pectinaria* (Hübner) 28 June-11 Aug.
Benton, Clinton, Howard, Jackson, Jefferson, Pike, Randolph, St.
Louis, Washington.

163. *Euchlaena tigrinaria* (Guenée) 14 Apr.-20 Aug.
Benton, Clay, Clinton, Franklin, Howard, Jackson, Jasper, Jefferson, Newton, Randolph, St. Louis, Washington.
164. *Euchlaena irraria* (Barnes & McDunnough) 7 June
Franklin, Jasper, Oregon.
165. *Xanthotype sospeta* (Drury) —dubious—
St. Louis. Schroers (1914, p. 61 as *X. crocataria* (Fabricius)).
Probably in error for *X. urticaria* Swett.
166. *Xanthotype urticaria* Swett 3 May-20 Sept.
Bates, Benton, Boone, Clay, Cooper, Franklin, Greene, Howard, Jackson, Jasper, Lafayette, McDonald, Pemiscot, Pike, Platte, Randolph, St. Charles, St. Louis, Shannon, Shelby, Washington.
167. *Cepphis armataria* (Herrich-Schäffer)
Missouri. Packard (1876, p. 511).
168. *Plagodis fervidaria* (Herrich-Schäffer) 3 July-11 Aug.
Jasper, Newton, St. Louis, Washington.
169. *Plagodis alcoolaria* (Guenée) 8 Apr.-12 Aug.
Benton, Clay, Franklin, Jackson, Jasper, Newton, Ralls, Randolph, St. Louis.
170. *Plagodis phlogosaria purpuraria* Pearsall 4 May-27 July
Clay, Randolph.
171. *Hyperetis alienaria* (Herrich-Schäffer) 3 Apr.-12 Aug.
Franklin, Jasper, Newton, St. Louis, Washington.
172. *Hyperetis amicaria* (Herrich-Schäffer) 14 Apr.-5 Oct.
Benton, Clay, Franklin, Jackson, Jasper, Jefferson, Randolph, St. Louis.
173. *Nematocampa filamentaria* Guenée 25 May-7 Aug.
Benton, Clay, Franklin, Greene, Jackson, Jefferson, St. Louis.
174. *Metarrhantis mollicularia* (Zeller) 27 Apr.-24 July
Benton, Jasper, St. Clair.
175. *Metarrhantis hypochraria* (Herrich-Schäffer) 29 May-20 June
Benton, Boone, Clay, Franklin, Jackson, Oregon, St. Louis, Washington.
176. *Metarrhantis homuraria* (Grote) 14 Apr.-30 July
Benton, Clay, Jackson.
177. *Metarrhantis warneri warneri* (Harvey) 18 May
Clay.
178. *Metarrhantis duaria* (Guenée) 14 Apr.-29 May
Benton, Clay, Jackson, Jasper, St. Clair, St. Louis.
179. *Metarrhantis angularia* Barnes & McDunnough 15 May-9 June
Benton, Jackson, Jasper, Moniteau.
180. *Metarrhantis obfirmaria* (Hübner) 1 May
Oregon, St. Louis.
181. *Metanema inatomaria* Guenée 17 May-26 Sept.
Benton, Clay, Jackson, Jefferson, Pike, Randolph, St. Louis, Vernon.
182. *Metanema determinata* Walker 8 Aug.
Pike.
183. *Selenia alciphearia* (Walker) —dubious—
St. Louis. Schroers (1913, p. 356).
184. *Selenia kentaria* (Grote & Robinson)
Jasper.
185. *Sphacelodes vulneraria* Hübner
Boone.
186. *Pero honestarius* (Walker) 3 May-26 Aug.
Benton, Clay, Jackson, Jefferson, St. Louis.
187. *Pero marmoratus* Grossbeck 8 Apr.-1 Sept.
Benton, Boone, Clay, Franklin, Howard, Jackson, Jasper, Platte, Randolph, St. Louis, Washington.

188. *Philtraea monillata* Buckett 14 June-29 Aug.
Jefferson, St. Louis.
189. *Lambdina pellucidaria* (Grote & Robinson) 8 Apr.-16 Apr.
Benton, Jasper.
190. *Lambdina athasaria* (Walker) 20 July-5 Aug.
Clay, Jackson, Randolph.
191. *Lambdina fiscellaria* (Guenée)
St. Louis. Schroers (1914, p. 61 as *Therina fervidaria* (Hübner)).
192. *Besma endropiaria* (Grote & Robinson) 26 May
Benton, St. Louis.
193. *Besma quercivoraria* (Guenée) 15 Apr.-5 Sept.
Benton, Clay, Franklin, Jackson, Jasper, Jefferson, Newton, Randolph, St. Louis, Vernon, Washington.
194. *Lychnosea intermicata* (Walker) 12 June-24 Oct.
Benton, Boone, Clay, Clinton, Carter, Jackson, Newton, St. Clair.
195. *Ennomos subsignarius* Hübner 10 May-5 July
Boone, Jackson, Jasper, Newton, Pike, St. Louis, Vernon, Washington.
196. *Ennomos magnarius* Guenée 2 July-31 Oct.
Boone, Clinton, Greene, Jackson, Jasper, Johnson, Nodaway, Pike, Randolph, St. Louis.
197. *Apicia confusaria* (Hübner) 15 May-7 Sept.
Benton, Boone, Cape Girardeau, Clay, Franklin, Greene, Hickory, Jackson, Jasper, Jefferson, Lafayette, Lincoln, Moniteau, Montgomery, Newton, Pike, St. Clair, St. Louis, Shannon, Vernon, Washington.
198. *Syssaura olyzonaria* Walker 15 May-2 Nov.
Benton, Boone, Camden, Clay, Franklin, Howard, Jackson, Johnson, Newton, Pike, Randolph, Washington.
199. *Tetracis crocallata* Guenée 2 May-7 Aug.
Benton, Clay, Greene, Jackson, Jefferson, Pike, St. Louis.
200. *Tetracis cachexiata* Guenée 10 May
Jasper, St. Louis.
201. *Abbotana clemataria* (J. E. Smith) 4 Apr.-17 Aug.
Benton, Boone, Clay, Franklin, Greene, Jackson, Jefferson, Newton, Pike, Platte, St. Louis, Washington.
202. *Antepione thisoaria* (Guenée) 22 Apr.-31 Aug.
Benton, Greene, Jasper, Newton, St. Louis.
203. *Prochoerodes transversata* (Drury) 8 Apr.-11 Oct.
Bates, Benton, Caldwell, Camden, Cape Girardeau, Clay, Clinton, Greene, Jackson, Jasper, Lafayette, Newton, Pike, Platte, Randolph, St. Louis, Taney.

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VARIATION IN *COLIAS NASTES*
OF LAPLAND
(Cover illustration)

Pattern variation of *Colias nastes* and *Colias hecla* varies from locality to locality according to degree of hybridization between these two circum-polar species, and the particular climatic conditions to be found. The color illustration shows (top left) a male *C. hecla*, which is orange, followed by males of *C. nastes* (yellow) in series arranged according to the border pattern from *hecla* at left to *nastes*, right.

A detailed analysis of these variations in various parts of the distribution of the species will appear in a forthcoming issue of the Journal.

William Hovanitz

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NOTICES

WANTED:

Moths of the family Hepialidae in papers or sealed in container with chlorocresol, also larvae and pupae in Bles or similar solution, for distribution study of North American species. Norman E. Tindale, 2314 Harvard Street, Palo Alto, Calif. 94306.

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Records of Speyeria zerene hippolyta. Edwin M. Perkins, Div. Biol Sci., University of Southern California, University Park, Los Angeles, Calif. 90007.

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INSECTS, catalogue. Combined Scientific Supplies, P.O. Box 125, Rosemead, Calif. 91770.

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IN THIS ISSUE

- On the origin of austral elements in
the moth fauna of south-eastern Ontario,
including a number of species new for Canada
R. Harmsen, P. D. N. Hebert and P. S. Ward 127
- The study of populations of Lepidoptera
by Capture-Recapture methods
P. M. Sheppard and J. A. Bishop 135
- Life history studies of *Idaea obfusaria* (Walker)
Roger L. Heitzman 145
- Survey of ultraviolet reflectance
of Nearctic butterflies James A. Scott 151
- Butterflies of St. Croix Charles F. Leck 161
- An improved method for rearing the
Monarch butterfly Charles Munger 163
- An annotated checklist of the Missouri
Geometridae Roger L. Heitzman 169
- Cover Illustration:
Variation in *Colias nastes* of Lapland
William Hovanitz 180

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ADULT BEHAVIOR AND POPULATION BIOLOGY OF TWO SKIPPERS (HESPERIIDAE) MATING IN CONTRASTING TOPOGRAPHIC SITES

JAMES A. SCOTT

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Abstract. *Hesperia pahaska* mates on ridgetops and hilltops, whereas the closely related species *Ochlodes snowi* mates in gullies, so that there is little interference between the two. Other behaviors are almost identical in the two species: the method of mate-location in which males sit at characteristic sites and dart out at passing objects in search of females, the time of day of mating, courtship, the rejection dance of unreceptive females, population movements which are fairly large, lifespan, feeding behavior, oviposition, and basking behavior. Interference between species occurs because perching males investigate individuals of related species and numerous interspecific courtships were observed, but is minimized by separate mating locations. The location of mating may not evolve due to interference, but probably evolves in the topographic sites most frequent in the range of a species.

INTRODUCTION

IT HAS GENERALLY BEEN ASSUMED that most butterflies mate throughout their habitat. This paper provides evidence that closely related species can mate in very different topographic situations, resulting in little interference between species. Two species were chosen for study: *Hesperia pahaska* Leussler and *Ochlodes snowi* Edwards. They are sympatric at the *Ochlodes* study site and elsewhere at the upper elevational limits of *H. pahaska*. Additional data is presented on two other sympatric species of *Hesperia* which mate in gullies and small plateaus, which show little interference with the sympatric *Hesperia pahaska*. Both species are perching species; perching behavior is defined as a mate-locating system in which males sit at characteristic sites and dart out at passing objects in search of females. It is the opposite of patrolling behavior, in which males fly almost continuously in search of females.

All times are given as 24-hour standard time. I thank Jerry A. Powell for criticizing the manuscript.

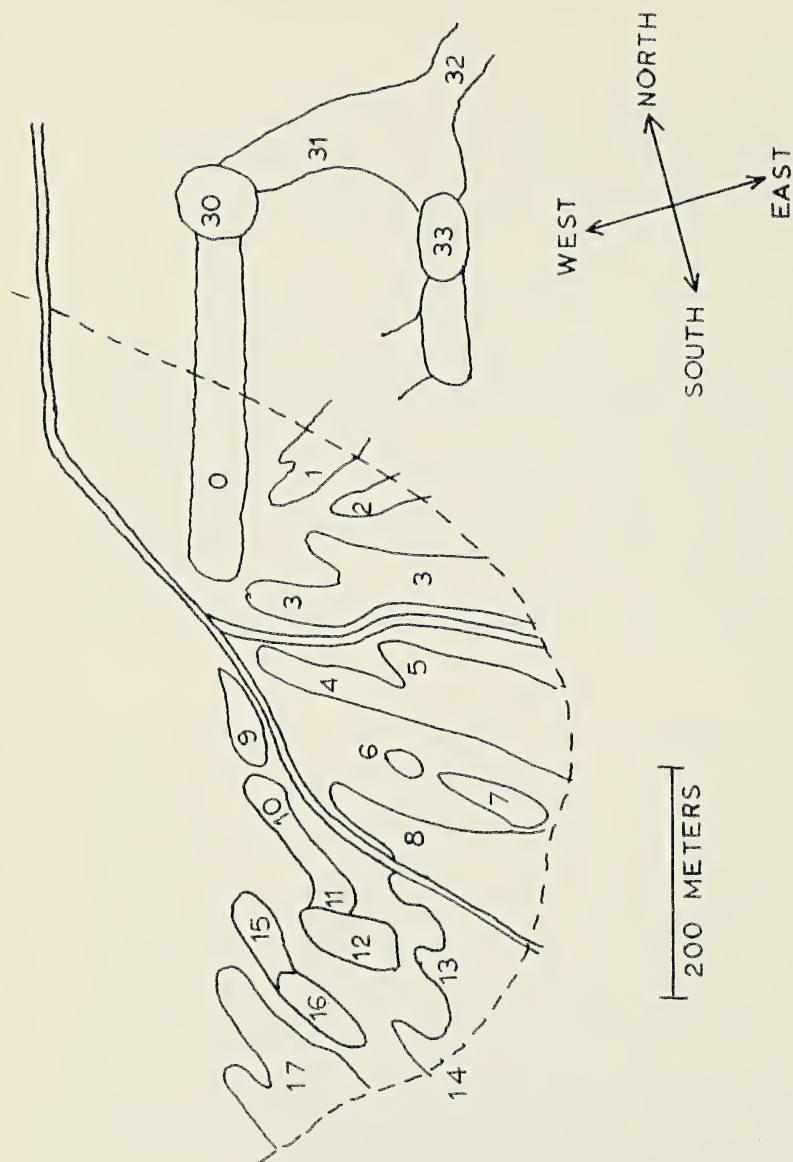


Fig. 1.—Map of the study site of *Hesperia pahaska*. Numbers are area designations; lines outline hills and ridges; double lines are dirt roads. Dashed line is the boundary of the Dry Union Formation (an easily eroded lake deposit) to the west, and metavolcanic gneiss to the east.

METHODS

Marks-A-Lot brand markers were used to give each individual a different number using the method of Ehrlich & Davidson 1960).

A new method of analysis of population movements is used that allows direct comparison between the sexes and between species, determination of change of movements with age, and separation of the velocity and distance aspects of movements. The capture points for an individual are plotted on a xeroxed map of the study site, one map per recaptured individual. The following are determined for each individual:

d_i t_i — distance in m and time in days between the i 'th and $(i+1)$ th captures

D — sum of all d 's of an individual (total distance)

R — distance in m between the two farthest capture points (range)

T — days between first and last capture

V = D/T (total velocity)

v_i = d_i/t_i (velocity)

Means of the above parameters for all individuals of a sex are computed. Midpoint age is the age midway between two successive captures of an individual after calling the first capture day 0. It was calculated without a correction for worn individuals since all the individuals were in fresh wing condition when first marked. Correlations between the above movement parameters and age determine whether movement changes with age.

Population size, survival rates, and number of new insects per day were found from mark-recapture data using the method of Jolly (1966). In setting up the initial table for the Jolly method, each individual is entered into the table one time less than the number of captures. For example, an individual captured on days 2, 6, 11, and 13 is entered three times, at positions 2-6, 6-11, and 11-13.

Hesperia pahaska (Hesperiinae)

This species was studied in June of 1969 and 1970 at low hills in Chaffee County, Colorado, SW $\frac{1}{4}$ sec. 14 and NW $\frac{1}{4}$ sec. 23, T. 49 N., R. 9E. (fig. 1). *H. pahaska* is found slightly more commonly on the gneiss areas of Fig. 1 but is present everywhere.

Mate-locating behavior. Males perch on stones and other objects from 0700 to as late as 1730, usually from 0730 to 1630. Almost all perching and mating occurs on hilltops and ridgetops, especially hilltops 30, 33, and 12, and sloping ridge 0 (Fig. 1). Perching males sit with wings above the thorax and dart out at passing objects. Males often return to the same spot after an investigative flight. Males are not territorial because movements are fairly large and males often do not return after an investigative flight. Chases between males are more frequent than chases with other species, especially *Amblyscirtes simius* Edwards. There is often "competition" for space, because to avoid interference males must perch more than 3 m from each other. The males not on ridgetops are temporarily at flowers and on hillsides. In one favorable spot on a ridge or hilltop, often 10 males can be collected in an hour as other males move there. At lower densities at other localities competition is also fairly high because males are concentrated on the most favorable hilltops.

Very recently emerged males are less active and old males tend to visit flowers more and perch slightly less than other males.

The few males on hillsides are not as important in mating as the males on hilltops. Males on hillsides do not perch much. They feed and court females on flowers that are usually already mated and unreceptive.

The three species of *Hesperia* at Bear Creek divide up the habitat so that interference between species is minimized. Males of *H. pahaska* perch on ridgetops and hilltops; males of *Hesperia viridis* Edwards perch only on stones or bare spots in the bottom of gullies, especially a small gully southwest of 30 and the gully between 0 and 1. Males of *Hesperia uncas* Edwards perch only on two slight rises in the small 5 m high plateau 3. The larval host of all three is the same, and females of *pahaska* and *viridis* oviposit in the same areas of the hillside of 0, whereas *uncas* females oviposit on the low plateaus like 3 and on the flats around low plateaus. This habitat separation is not restricted to Bear Creek, as I have collected each of the three species at over 50 localities in south-central Colorado, Nevada, Utah, Arizona, and Texas, and everywhere their behavior is the same. In some localities *H. pahaska* perches on the high point of a sloping ridge while *uncas* perches lower down on the ridge. Above 2440 m *viridis* drops out, and below 2440 m normally only *viridis* and *pahaska* occur together, since

uncas requires flatter areas. *H. viridis* is multiple brooded, so normally *H. pahaska* and *viridis* occur together in Colorado only during June and early July. The perching site is probably an evolutionary result of the habitat in most of the range, which is mountain chaparral for *H. pahaska* and great plains for *H. viridis* and *H. uncas*.

Three closely related sympatric skippers have habits similar to the *Hesperia*. *Stinga morrisoni* Edwards perches on hilltops, but only on hilltop 33 and higher hills to the east, perhaps because of lower density in *morrisoni*, while females occur on the same hillsides as *H. pahaska*; it flies slightly earlier than *H. pahaska*. *Yvretta rhesus* Edwards has habits similar to *H. uncas*, but flies about three weeks earlier so is usually gone when *uncas* appears. *Amblyscirtes simius* perches on low hilltops including ridge 0 and hills 1, 2, 3, 12, etc.; this species differs from the previous species in mating only during part of the day, from about 0740 to 1050. Many other perching butterflies there are unrelated enough to cause little interference. Certainly the habitat separation is not the only isolating mechanism, which probably includes olfaction since the courtship is the same in most *Hesperia* species (MacNeill, 1964).

Mating. Two completed courtships were seen. A female flies past the perched male, who flies to within 5 cm. of the female. The female lands, the male may flutter about the female for a short time, then he lands, crawls beside the female and bends the abdomen laterally to copulate. The male sometimes flutters his wings rapidly with moderate amplitude after landing, and the female may flutter her wings slightly or crawl or fly a short distance. *Hesperia metea* Scudder has similar courtship (Shapiro, 1965). Many courtships of unreceptive *pahaska* females were observed. In these courtships the female upon landing almost always fluttered her wings from vertical to horizontal about 10 times per second. I believe that this is a rejection dance because the females which did this and were later dissected were found to be mated, and because these courtships were never successful. Males often flew away when the female fluttered. The rejection dance inhibits male fluttering; males rarely fluttered behind fluttering females.

The male *Hesperia* has a pouch (stigma) on the front wing full of powder-like material (MacNeill, 1964), which may carry a pheromone. This pheromone may be species-specific because the powder color is different in different species. The male pheromone might be used when the male overtakes the female and flutters his wings.

The virgin female perhaps possesses a pheromone usable within a few feet, because males seem to remain behind virgin females longer than behind mated ones and males relocated several females by approaching from downwind.

Interspecific courtships sometimes occur between the three *Hesperia* species, *Ochlodes snowi*, *Stinga morrisoni*, and *Amblyscirtes simius*. The *Hesperia* female always responds to a male of these species by landing, and then an unreceptive *Hesperia* female usually flutters her wings. The males then often depart.

Females predominantly mate only once, but older females often mate twice and one very worn female was mated three times (table 1). Mated females have a small solid plug in the genital opening, which is evidently ineffective in preventing multiple mating.

Perching, courting, and mating occur at all times of the day in favorable weather. 32 courtships were seen from 0736 to 1644. Copulating pairs were found at 0814, 0830, 1128, 1201, 1312, 1431, and 1544. All matings occurred on the ridge or a hilltop or (twice) within 7 m of a hilltop where they could have flown after a disturbance. Ten virgin females were found from 0812 to 1600, indicating that at least some females wait until the day after emergence to mate. Most of these virgins were found on ridgetops or hilltops where they had flown to seek males. The proportion of females caught on (usually) or within 10 m of a ridgetop or hilltop where perching occurred that were virgin was 32% (13 of 40); the same proportion on hillsides was only 7% (2 of 30). Virgins emerge in early morning (based on laboratory emergence) and apparently remain near the emergence site (usually a hillside) while teneral, then fly to a hilltop to encounter a male on that afternoon or the next day.

Movements. In 1969 the species was marked and captured over the entire area (fig. 1; Table 2). The recaptured males moved 20, 101, 107, 107, 148, 161, 208, 362, and 583 meters, the last two movements in 8 and 10 days respectively. The female moved 20 meters in less than an hour. Several of these individuals crossed the area. The study area was found to be too large for studying dispersal of *Amblyscirtes simius* which was studied concurrently, so in 1970 only areas 0 to 3 and 30 to 34 (fig. 1) were studied. As expected, 1970 distances moved were less than 1969 distances, but velocities were similar. The distances and velocities moved for females are smaller than for males, which may be due to only 8 female recaptures.

Table 1. Relationship of number of matings per female to apparent age (wing condition) of the female in *Hesperia pahaska*.

Number of Spermatophores	WING CONDITION					Total
	0	Young 10		Old		
	1	19	19	13	5	2
	2	2	1	1	4	8
	3					1

Table 2. Movement data for *Hesperia pahaska*. N = sample size; n = not significant; * = significant at .05; ** = significant at .01; significance of correlations determined by tests of zero correlation.

Dispersal Parameter	1969		1970		1970	
	Males	N	Males	N	Females	N
Number Marked	60		199		53	
Number Recaptured	9		64		8	
Average T (days)	4.44	9	4.03	64	3.87	8
Average ti (days)	3.33	12	2.53	102	3.20	10
Average R (meters)	193.	9	140.	64	101.	8
Average D (meters)	199.	9	174.	64	110.	8
Average di (meters)	149.	12	109.	102	88.	10
Average V (meters per day)	56.	9	59.	64	38.	8
Average vi (meters per day)	51.	12	59.	102	43.	10
Correlation di and ti			+.208*	102		
Partial Correlation di & ti, Age Constant			+.207n	102		
Correlation vi and Age			-.181n	102		
Correlation di and Age			+.032n	102		
Partial Correlation di and Age, ti Constant			-.025n	102		
Correlation ti and Age			+.267**	102		

MacNeill (1964) states: "it is more often females than males which are encountered some distance from a habitable area," which indicates that females disperse more than males. Movements of males which are on ridgetops and hilltops are similar to movements of males on hillsides; many males moved from hillsides to the ridgetop, and vice versa.

There was a small correlation of distance with time between recaptures (table 2). Velocity declined slightly with age, and the time between recaptures increased with age, indicating a slight decrease in dispersal with age.

Population parameters. Males first started emerging about June 9, increased to a peak of about 300 on June 20, then decreased (table 3). The number of new butterflies averaged about 100 per day and gradually decreased. Average survival rate was .741, corresponding to expected lifespan of 3.3 days, using method 1 of Scott (1973). Average survival rate using method 2 (of Scott, 1973) was slightly higher because of day 23: .778 (4.0 days). The potential lifespan is over three times as long. Males lived at least ten (3 males), eleven (2), and twelve days (2). Females lived at least 9 and 10 days. Expected lifespan should be increased because probably many individuals dispersed out of the area.

Feeding. Both sexes often visit flowers. Females usually sit on the ground, bask, visit flowers, and occasionally oviposit. Both sexes visit flowers at all times of day, especially during the hottest part of the day at about 1230 (Fig. 2). Both sexes slightly prefer blue flowers over yellow and white ones, although visits are recorded to all colors. The contrast with *Callophrys siva* Edwards, another butterfly flying with *H. pahaska*, is striking; *C. siva* was common on the flowers of white *Cryptantha jamesi* and yellow *Melilotus officinalis*, and rarely visited other flowers. *H. pahaska* at the study site visited the following species: blue *Penstemon secundiflorus* (94 visits), yellow *Opuntia polyacantha* (43), white *Astragalus drummondii* (20), blue *Cirsium vulgare* (13), white *Cryptantha jamesi* (13) blue-white *Erigeron pumilus* (6), blue *Astragalus bisulcatus* (3), blue *Cleome serrulata* (3), red-blue *Oxytropis lamberti* (3), yellow *Melilotus officinalis* (2), yellow *Hymenopappus filifolius* (2), white *Aster arenosus* (1), white *Asclepias incarnata* (1), yellow *Descurainia sophia* (1), blue *Mirabilis multiflora* (1). Elsewhere they also visited blue *Aster bigelovii*, yellow *Heterotheca villosa*, yellow *Sedum lanceolatum*, yellow *Erysimum asperum*, yellow *Thamnosma montana*.

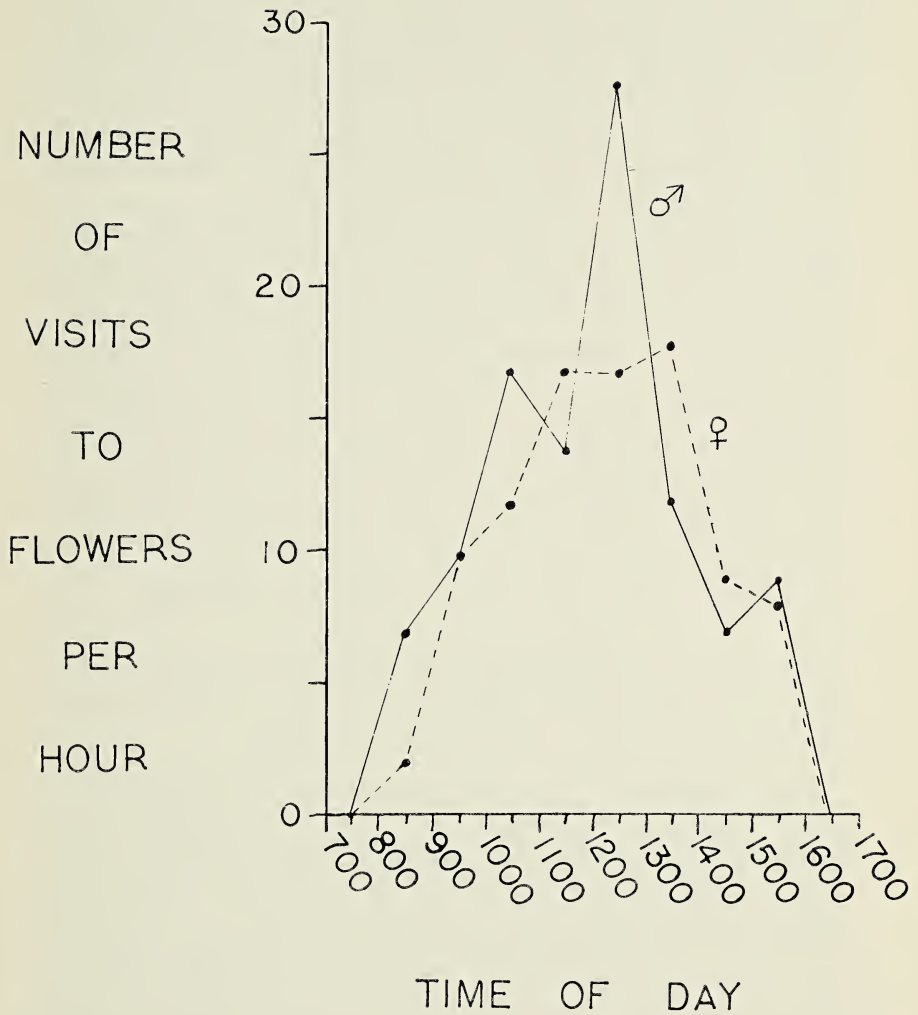


Fig. 2.—Number of visits to flowers at various times of day for both sexes of *Hesperia pahaska*.

Oviposition. Females oviposited on the grass *Bouteloua gracilis*, the probable larval host. An ovipositing female flutters slowly over an area with abundant *Bouteloua*, lands and lays an egg on the lower surface of one of the leaves, usually near the outer edge of a clump. Oviposition was observed throughout the day from 935 to 1427 with a strong preference for warm, sunny midday hours. Oviposition and other female activity occurred mostly on hillsides, especially the west and southeast slopes of ridge 0. Females seldom oviposit on hilltops, since they are constantly investigated by males there.

Thermoregulation. In cool or cloudy periods both sexes bask by spreading the front wings open about 45° from vertical and hind wings about 70° from vertical. Usually they face away from the sun for maximum insolation, but near midday they face into the wind in the landing position and fail to turn. On hot days (above 80°F) at midday most activity ceases and both sexes seek the shade of a pinon tree or land on its boughs to avoid the hot ground. The study period in 1969 was cold and windy and no individuals were seen to do this, but 1970 was hot in late June and numerous individuals sought shade and trees. Individuals often visit flowers and bask in mild cloudy weather but rarely visit flowers in very hot weather.

Predation. Only one male was caught by a robberfly.

Ochlodes snowi (Hesperiinae)

This species was studied in 1969 in Saguache County, Colorado, near center sec. 22, and NW¼ sec. 23, T. 46 N., R. 8 E., and in 1970 at Rosita, Custer County, Colorado.

Mate-locating behavior. Males perch all day on stones, twigs, or short vegetation in the bottoms of dry narrow gullies which erode during heavy rains but are usually dry. Courtships occur in gullies and at flowers, where females are greatly concentrated. A few males perched in depressions on hillsides and several males perched briefly in the depression between a shrub and the hillside. Perching males fly within about 10 cm of a passing object, then usually return near the last perch. Males investigate objects of the same size range as does *H. pahaska*. In 40 minutes, one male chased 17 other *Ochlodes* males, 9 small flies, 1 2-cm beetle, four brown, black, or blue butterflies less than 3 cm wingspan, and did not chase 5 other butterflies with wingspan 3 cm or greater. When two adjacent males chase each other, they both often rise into the air for 5 meters and rarely up to 30 meters, then separately return to the ground. Males take up a space in the gully about 5 meters long. The species

is usually not abundant, except rarely at flowers, so there is less competition for perching sites than in *H. pahaska*. Most mating undoubtedly occurs in gullies because all females on flowers were unreceptive, and flowers were mostly in glades in stream bottoms near where males perch rather than on hillsides. Males are not territorial because they often do not return to the last perch and move large distances (see below).

Mating. When a female passes by a perched male, or when a female and a male visit the same flower, courtship occurs. If the female flies past, the male approaches within a few cm. This causes the female either to land, or to hover about 3 cm above the ground. If the female hovers, the male hovers also, and moves sideways behind and around the female and now and then moves forward contacting her. Both sexes hover by beating their wings rapidly at wide amplitude. In the one completed courtship, the female landed after the male approached, the male fluttered slightly, landed, and bent his abdomen laterally to copulate. Only two copulating pairs were found, which was surprising since 55 courtships were observed. The male bends his abdomen to attempt joining when the female is on the ground or on a flower. The fluttering of the female on a flower may be the rejection dance of the female, because the male leaves fluttering females after usually 10 seconds or occasionally a minute. The hovering was done usually by mated females. In four courtships in which the female was later found to be virgin, only one of the females hovered while the male fluttered about her; the other three merely sat on the ground with the male behind.

The male has a stigma as in *Hesperia*, which may emit a pheromone. Females may possess a pheromone, because males remained behind virgin unreceptive females for an average of 15 minutes ($N = 6$). Males remain near females which were mated 1 to 3 times an average of only 7.4 seconds ($N = 22$).

Two copulating pairs were found in gullies at 916 and 1452. The 55 courtships occurred from 900 to 1535.

Males of all ages, except very recently emerged males, engage in courtship, so males probably can mate many times. Females can mate up to 5 times, and older females are mated an average of 3 times (table 4). Seven virgin females were found from 910 to 1601, indicating that at least some females wait until the day after emergence to mate. Four virgins were found on hillsides, and three were found in gullies. Three of the virgins were visiting flowers, and one was sitting in shade.

Movements. A mark-recapture study was carried out in 1969 at the Saguache County site (Table 5). This area consisted of several gullies separated by ridges and hilltops. Males can move large distances; two males moved 1610 meters to another valley, and a female moved 140 meters. Because this species flies extremely fast, it is not surprising that individuals fly large distances.

Population parameters (Table 6). Average survival rate and corresponding expected lifespan for males was .785 (4.1 days) using method 1 and .736 (3.3 days) using method 2 and ignoring days 16 and 17. These rates should be increased somewhat since many individuals undoubtedly dispersed out of the area. The potential lifespan is much larger; 3 males lived 8 days, and 3 males lived 9 days.

Feeding. Both sexes often feed, especially during the warmest part of the day. Both sexes prefer blue flowers. *O. snowi* in Saguache County visited the following: red-purple *Oxytropis lamberti* (115), blue *Penstemon secundiflorus* (95), blue *Astragalus* sp. (15), blue *Penstemon virgatus* (8), yellow *Hymenopappus filifolius* (4), pink *Geranium caespitosum* (3), blue *Lupinus argenteus* (2), blue *Linum lewisii* (2), red *Gilia texana* (1), white *Cryptantha jamesi* (1), yellow *Potentilla* sp. (1), cream-white *Eriogonum jamesi* (1), pink *Allium* sp. (1). At Rosita they visited a purple legume species (10), *Oxytropia lamberti* (8), *Lupinus argenteus* (2), and pink *Geranium* sp. (1).

Oviposition. Two ovipositions were observed at Rosita, at 1025 and 1035. The female hovers over the most common grass on the west-facing slope where oviposition occurred, *Blepharoneuron tricholepis*. She flies back and forth about 20 cm above the ground and finally lands and oviposits on a leaf at the edge of a clump of this grass. Other females hovered over this grass but did not oviposit.

Thermoregulation. Basking is very similar to that of *H. pahaska*. Upon landing, individuals face uphill, or into the wind, or along a twig. If none of these factors is involved, individuals usually face away from the sun when basking. In cold or cloudy weather, individuals merely sit on the ground with wings closed and may fly very short distances. Early in the morning several males sat on the sunlit east facing side of a gully. Only two males were observed to seek shade because temperature rarely was hot.

Predation. Two males were caught by robberflies at the Saguache County site. The following unusual behavior may lessen predation by vertebrates. After disturbance due to handling for marking, males flew to a nearby tree or shrub and remained there for about 5 minutes. Twenty males did this at all times of day.

DISCUSSION

The behavior of these two species is almost identical except for the location of mating. Perching males investigate objects of many different colors and sizes (Tinbergen et al., 1942; Stride, 1956; Scott, unpublished); in *Hipparchia semele* L. males investigated objects of all colors equally frequently except that white evoked slightly fewer responses (Tinbergen et al., 1942). The wide range of colors and sizes pursued and the frequent interspecific courtships observed mean that considerable interference occurs between species. This interference is minimized by the separation of mating sites where the two species studied are sympatric, as at the *Ochlodes* study-area. The location of mating is correlated with the topographic sites frequent in the range of a species, so interspecific competition may not directly cause evolution of different mating sites. Gullies are frequent in the habitat of *Ochlodes snowi*, but hilltops are less common and are often forested, making them less suitable for perching behavior (but *H. pahaska* males perch there). In the chaparral habitat of *H. pahaska*, hilltops are common, while gullies and small mesas are frequent in the plains habitats of *Hesperia viridis* and *H. uncas*. In many butterfly species males show mate-locating behavior near the larval foodplant, where females are likely to be found, but in *Ochlodes* and *Hesperia* the larval foodplant grasses are widely scattered, so that a strategy of meeting of the sexes in topographic sites is favored. Scott (1968) showed that rare species are much more likely to be hilltopping species, and that hilltopping is a mating mechanism that enables survival at low density by bringing more individuals together for mating than would mate if mating occurred throughout the habitat.

Table 3. *Hesperia pahaska* males, 1970. Population parameters estimated from multiple recapture data using the stochastic model of Jolly, 1966. Alpha—proportion of marked animals; M—total marked population; N—total population; Phi—probability of survival; B—number of new animals joining the population; SE—standard error.

Day	Alpha	M	N	1.96 SE	Phi	1.96 SE	B	1.96 SE
June 9-11	—	—	—	—	.675	.589	—	—
17	.1143	10.80	94.5	+ 103.1	.755	+ .536	299.2	+ 433.4
18	.0833	30.82	369.8	+ 451.1	.906	+ .641	-32.2	+ 403.1
19	.1860	56.00	301.0	+ 256.4	.746	+ .544	209.1	+ 336.3
20	.1522	65.64	431.3	+ 380.2	.499	+ .343	-93.3	+ 169.2
21	.4211	50.75	120.5	+ 89.7	1.198	+ .947	210.8	+ 310.1
22	.2083	74.00	355.2	+ 357.8	.645	+ .482	115.8	+ 322.4
23	.1724	59.36	344.3	+ 315.0	1.322	+ 1.184	-132.5	+ 383.8
24	.3333	106.25	318.7	+ 286.6	.349	+ .371	50.4	+ 78.7
25	.2545	38.50	151.2	+ 115.2	.416	+ .411	12.8	+ 43.6
26	.2727	16.00	58.7	+ 50.8	—	—	—	—
27-(28, 29, 30)	.0833	—	—	—	—	—	—	—

Table 6. *Ochlodes snowi* males, 1969. Population parameters estimated from multiple recapture data using the stochastic model of Jolly, 1966. Alpha—proportion of marked animals; M—total marked population; N—total population; Phi—probability of survival; B—number of new animals joining the population; SE—standard error.

Day	Alpha	M	N	1.96 SE	Phi	1.96 SE	B	1.96 SE
July 16	—	—	—	—	2.833	+ 2.560	—	—
17	.0625	8.50	136.0	+ 294.1	1.489	+ 2.268	234.5	+ 961.8
18	.0769	33.50	435.5	+ 1025.8	.549	+ .952	-39.3	+ 583.8
19	.1250	25.00	200.0	+ 445.4	.964	+ 1.352	208.3	+ 577.3
21	.0769	30.86	401.1	+ 558.7	1.040	+ 1.170	521.2	+ 429.6
22	.0741	69.50	938.2	+ 1571.7	.561	+ .743	268.8	+ 677.1
23	.0667	53.00	795.0	+ 1715.5	.938	+ 1.779	-286.5	+ 527.7
24	.1316	60.00	456.0	+ 844.7	.700	+ 1.655	-65.1	+ 318.6
25	.1818	42.00	231.0	+ 413.5	.381	+ .856	-1.7	+ 88.2
26	.2105	16.00	76.0	+ 126.6	—	—	—	—
27	.1818	—	—	—	—	—	—	—

Table 4. Number of matings per female versus apparent age (wing condition) in *Ochlodes snowi*.

		WING CONDITION					
		Young				Old	Total
NUMBER	0	7					7
OF	1	19	14	3			36
MATINGS	2		2	7	2		11
PER	3		1	2	1	1	5
FEMALE	4			4			4
	5				1		1

Table 5. Movement data for *Ochlodes snowi*, 1969. For explanation see Table 2.

Dispersal Parameter	Males	N	Females	N
Number Marked	108		4	
Number Recaptured	23		2	
Average T (days)	3.96	23	0.	2
Average ti (days)	3.14	29	0.	2
Average R (meters)	181.	23	90.	2
Average D (meters)	184.	23	90.	2
Average di (meters)	146.	29	90.	2
Average V (meters per day)	32.	23	90.	2
Average vi (meters per day)	37.	29	90.	2

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ACCEPTANCE OF ARTIFICIAL DIET BY
MEGATHYMUS STRECKERI (SKINNER)
(MEGATHYMIDAE)^{1 2}

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WIELGUS AND WIELGUS (1972) DESCRIBED some techniques and problems involved in rearing several species of *Megathymus*. They found that the acquisition and preservation of food plants were particularly critical because *Megathymus* larvae are host specific; that is, they feed on *Yucca* spp. Therefore, we investigated method of introduction and acceptance of an artificial medium for *M. streckeri*.

The diet that was adopted is a modification of that described by Henneberry and Kishaba (1966) which is commonly used at Mesa, Arizona, for rearing the cabbage looper, *Trichoplusia ni* (Hubner). The following ingredients are used to prepare a 1-gal. batch (cost ca. \$2.70): 2500 ml H₂O, 90 g agar, 129 g casein, 54 g alfalfa meal (autoclaved to prevent possible bacterial contamination), 18 ml 4M potassium hydroxide solution, 129 g sugar, 108 g wheat germ, 36 g Wesson[®] salt, 18 g alphacel, 36 ml (10% aqueous) choline chloride, 15 ml 27% formalin (10% formaldehyde gas in water), 20.6 ml each of 38% solutions of sorbic acid and methyl p-hydroxybenzoate in 95% ethanol, 15 g ascorbic acid and 0.5 g Aureomycin (chlortetracycline) suspended in 33.3 ml H₂O, and 12 ml vitamin solution (made from 2400 mg each niacin and calcium pantothenate; 1200 mg riboflavin; 600 mg each thiamin, pyridoxin, and folic acid; 48 mg biotin; and 4800 mg (0.1%) vitamin B₁₂ suspended in 400 ml H₂O).

¹In cooperation with the University of Arizona Agricultural Experiment Station, Mesa, Arizona 85201.

²Mention of a proprietary product does not constitute an endorsement by the USDA.

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Immediately after the hot liquid diet is prepared it is poured into a mold made of a 7.62-cm diam. plexiglass tube at least 12.7 cm long, and allowed to solidify at 23°C. Then a 12.7-cm-long section of diet is removed from the mold and placed in a polyethylene sandwich bag, the bag sealed to slow the loss of moisture, is inverted and supported upright by placing it in a pint glass jar. In the first trials, a 10-mm hole was cut in the top of the bag, a paper "tent" (Wielgus and Wielgus, 1972), was set ca. 6.5 mm into the diet, and a larva was placed inside the tent and allowed to make its own way. However, establishment did not occur within 24 hr. Therefore, in the second attempt (same larva), the tent was placed around a slice of yucca caudex pulp (25.4 mm long with a triangular top 3.2 mm on a side), and the slice was inserted into the diet so the broad end was flush with the surface of the medium. Juice from the diet was soaked up by the paper. It probably also soaked into the pulp making it the initial point of introduction of diet to the larva.

Larval feeding on the pulp slice produced a pebbly, cream-colored frass; larval feeding on diet produced a fine textured, brownish-colored frass.

After the demonstration of acceptance, three *M. streckeri* reared from eggs (2 collected 15 mi. S.W. of Winslow, Arizona, and one collected in the Sandia Mountains, New Mexico) on yucca caudices were transferred to the diet, two as 3rd-instar larvae and one as a 4th-instar larvae. Throughout the tests temperature and relative humidity were maintained at 25.6°C and 40%, respectively.

The acceptance of the artificial diet by *M. streckeri* reduces the cost of rearing the insect and also makes it possible to rear the insect when one is not located near natural food sources.

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SOME OBSERVATIONS ON THE EGGS OF MOTHS AND CERTAIN ASPECTS OF FIRST INSTAR LARVAL BEHAVIOR

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Note: Any figure numbers mentioned in this paper refer to egg photographs in the preceding paper (pp. 10(3): 215-247).

THE TIME REQUIRED FOR EGGS of the same moth species to hatch can vary tremendously with the temperature. It should always be stated under what conditions the eggs were kept and the month (or season) involved. (Outdoors: In the same habitat as the moth occurs? Indoors: Controlled conditions or fluctuating with the weather changes?) When kept unheated indoors, in the locality in which the species occurs, and subject to the normal day-night fluctuations of that locality, the great majority of species will hatch within a period of about 4 to 18 days, if they are not spp. that overwinter or aestivate as eggs. (In all instances where the number of days to hatch is mentioned for species, at the ends of the commentaries in the preceding paper, conditions under which those eggs were kept fit the last-described circumstances). Typical examples of variation in the number of days required for eggs of the same species to hatch (in the *same* locality but at different times of the year), are recorded in the commentaries for Fig. 6 and Fig. 31 of the preceding paper.

Some moths, especially univoltine species with autumn- or winter-emerging adults, in regions having a Mediterranean climate, will spend anywhere from 3 weeks to several months in the egg state. Of the 182 spp. of Australian "Macrolepidoptera" (representing 22 families) which I have reared from eggs in South Australia to date, I have encountered only one species which appears to approach overwintering in the egg stage here: *Epicoma tristis* Lewin (NOTODONTOIDEA-Thaumetopoeidae;

N.McF. code-number *Ta.8*). Even this one (possible) example needs more evidence to fully verify my suspicions. Some South Australian moths pass *part* of the winter as eggs (4 to 9 weeks), a not uncommon form of "partial overwintering" here. Most of these larvae hatch before the cold weather has ended, however.

In most species the adhesive which attaches the egg to the substrate is essentially colorless, although in some groups (Saturniidae, for example) it often colors the egg surface with irregular smudges of reddish-brown, or some other shade (depending on the species). The adhesive is generally more-or-less waterproof. This is imperative for the eggs of species having larvae that feed on the foliage of trees, shrubs, or high-climbing vines; such eggs could otherwise be easily washed from the foodplant leaves or stems during heavy rain. If this happened, the newly-hatched larvae would have little chance of finding their way back to the correct foodplant leaves during that short period after hatching when they are able to exist without food. Eggs lacking adhesive are often found among species having polyphagous larvae, root feeders, or feeders upon weeds, annuals, or other low plants that densely colonize areas of ground (bracken fern or *Pteridium*, for example). These moths often deposit or drop their eggs free (unattached); or the adhesive, if present, may be quite weak and the eggs readily become detached, which does not matter under these conditions. (The young larvae have little trouble finding their food near at hand when they hatch.) Such eggs are usually round, or at least approach a *spherical shape*. A South Australian example is the *Pteridium*-feeding ennomine geometrid, *Idiodes apicata* Gn. (Fig. 31).

Three fairly reliable indicators for the above (herbaceous, etc.) general foodplant categories are: Egg "*small*" for size of moth; *spherical* or nearly spherical egg shape; *lack of adhesive*, or only very weak adhesive. These clues can be of great assistance to anyone attempting to rear, from the egg, a species for which no foodplant was previously known. It eliminates most or all of the woody plants in the locality, and allows one to concentrate on the remaining flora. Exceptions, however, sometimes occur: In regions with the Mediterranean climatic pattern, where woody, sclerophyllous vegetation predominates (as in coastal southern and southwestern Australia), it is often typical of moths having larvae restricted to eating only (or primarily) the *young* and tender new leaves of woody sclerophyll trees or

shrubs, to produce eggs that are *also* small for the size of the moth. Such eggs may be of any shape, but are usually securely glued. Some examples of this latter condition, among southern Australian Geometridae, are: Oenochrominae—*Arhodia lasiocamparia* Gn. (Fig. 24); Ennominae—*Boarmia penthearia* Gn., *Capusa cuculloidis* Felder (Fig. 36), *Cleora displicata* Walker (Fig. 34), *Gastrinopa xylistis* Lower, and *Melanodes anthracitaria* Gn. (Fig. 39). Eggs appearing “large”, for the size of the moth—again, egg shape does not matter—more often than not imply feeders upon the foliage of *woody* plants, or the *mature* foliage of woody *sclerophyll* plants, or (occasionally) the leaves of grasses, especially the tougher perennial species. Newly-hatched larvae that cling with considerable or great tenacity are almost always feeders on (foliage of) woody plants, and they often have slow (or relatively slow) locomotion; this does not, of course, apply to *all* feeders on woody plants, but it has proven to be a very useful clue in numerous cases. I have repeatedly observed that species depositing eggs which look “small”, for the size of the moth, frequently have larvae which grow exceptionally fast; even though they start out at a smaller size, they often surpass the growth-rate of other larvae which originally hatched from relatively larger eggs, and were larger at the start. These faster-growing larvae are usually feeders on “soft” vegetation (tender low-growing annuals, weeds, or the *new* leaves of woody plants.) “Excellent contrasting examples of this phenomenon are seen in Figs. 37 and 39 of the preceding paper. *L. habrocosma* is a *much* smaller moth than *M. anthracitaria*, yet compare the egg measurements of these two species! The former feeds *only* on the tough, old (sclerophyll) leaves of its foodplant; the latter *only* on the tender new leaves of its (sclerophyll) foodplant.”

Moths possessing noticeably long and easily-extended ovipositors have the habit, more often than not, of ovipositing *into crevices*, under flakes of bark, into buds, or down between stems and sheaths of monocots, *etc.* Such eggs usually have thin or very easily-broken shells, and are often deposited in groups or masses, with no covering of scales or froth, *etc.* *Cleora displicata* Walk. (Fig. 34) is a good South Australian example. For success in obtaining eggs from such species in captivity, it is often worthwhile to provide rough paper towel, tightly folded fan-like (to create many crevices). Sometimes, a piece of paper tightly rumpled will do the same job. If they can be induced to

oviposit on paper, the eggs are more easily retrieved later, for study or photography. In some cases, however, rough or shredded bark or something closer to the texture of the actual substrate, as sought out by the moth in its habitat, must be provided in order to create the needed oviposition stimulus.

Interesting questions arise with reference to certain very "thin" or soft-shelled eggs, when the species involved deposit naked eggs in open or *exposed* situations—for example, on *Eucalyptus* leaf surfaces in the case of the Australian limacodid, *Pseudanapaea trigona* (Turner) (my Lm. 3). The entirely naked eggs of this moth (see also Fig. 4 and its commentary), are readily subject to desiccation if kept in certain types of containers, or if the leaves to which they were attached have been allowed to completely dry out. Perhaps, when on a *living* leaf surface, they may receive the required moisture-balance from the leaf stomata (during transpiration) immediately around and/or underneath the eggs(?) It is possible that among other Zygaenoidea (Limacodidae, Megalopygidae, or Zygaenidae, etc.), or among the Pyraloidea, there may be similar cases. Deeper investigation into this subject might produce some interesting results.

A phenomenon worth reporting, in connection with relative egg-sizes in different populations of a single species, has been noticed for one of the South Australian moths having a wide distribution that extends from coastal areas far into the arid interior. The moth involved is a notodontid, *Danima banksiae* (Lew.). (See also the commentary for Fig. 10.) Field-collected eggs of this species from a coastal population, 10 miles W. of Vivonne Bay, Kangaroo Island, South Australia—mid OCT. 1966—N. McFarland (my Nd.15B), had measurements as follows: 2.00-1.85 mm. (diameter) x 1.40-1.35mm. (height), based on a long series. Field-collected eggs of this species from a desert population, 72 miles S. of Kulgera (Northern Territory), in South Australia 25 May 67—N.McF. & T. Newbery (my Nd. 15D), had measurements as follows: 2.30-2.25 mm x 1.65 mm., based on 3 eggs only. The eggs of this latter (desert) population were notably so much larger than those of coastal populations (with which I was already familiar), that the size difference was immediately apparent, even in the field. Two perfect adults were reared from the 3 field-collected desert eggs, producing typical *D. banksiae*, hardly distinguishable (in size, maculation, or coloring) from coastal adults. The third was preserved as a last instar larva (in S.A. Museum, Adelaide—Nd.15D).

Other impressions gained (not enough data yet to clarify), concerning the relative egg sizes of coastal versus inland geometrids of certain related Australian genera and species, tend to further reinforce an idea that eggs of desert (or relatively dry area) populations are sometimes a little larger than eggs of the same species (or close relatives) having populations in coastal, more humid, or wetter localities. (See also remarks under Fig. 15, egg dimensions of *Cosmodes elegans*.) Further observations along these lines will probably uncover parallels in other regions.

Rain-hatched eggs: A number of South Australian geometrids (about 10 of the Ennominae and 2 of the Larentiinae which I have reared thus far) have what I shall refer to here as "rain-hatched eggs". The adults of these spp., without exception, emerge *between* mid March and late May (autumn to early winter), which marks the beginning of the heavy rains (and cooler weather) in coastal South Australia. The eggs of these species do not at first show any peculiarities, but, as the larvae develop inside and approach apparent readiness to hatch (the fully developed larvae being clearly visible through the more-or-less transparent shells) they persistently "refuse" to emerge until such time as water is applied to them. They will, in the more strict examples of this phenomenon (for example, the ennomine geometrid, *Mnesampela fucata*), shrivel up and die inside the eggs if ample moisture is not present when required to trigger emergence. Yet, if these eggs, when definitely *ready* to hatch, are watered, and the excess water is poured off, hatching will sometimes begin within 5 minutes of the wetting! (*Amelora amblopa* Guest—Ennominae; my G.143). If not that rapidly, they will almost invariably be out within 30 minutes to 3 hours, or in half a day at the most. Other examples of South Australian geometrids having rain-hatched eggs are: ENNOMINAE—*Amelora milvaria* Gn. (my G.114), *Chlenias (pachymela* Lower?) (G.106), *C. umbraticaria* Gn. (G.112), *Mnesampela lenaea* Meyr. (G.118), *Stathmorrhopa macroptila* Turner (G.99), *Stibaroma trigramma* Lower (G.104), *Thalaina angulosa* Walk. (G.100); LARENTIINAE — *Xanthorhoe heliacaria* (Gn.) (G.142).

There are a number of other South Australian geometrid species which appear to be on the borderline of this requirement. Examples are the *oenochromine*, *Cycloprorodes melanoxyta* (Meyr.) (my G.221), the desert *ennomine*, *Thalainodes macfarlandi* Wilson (G.180), the coastal *ennomine*, *Lophothalaina habrocosma* (Lower) (G.154), and the *larentine*, *Xanthorhoe*

vicissata (Gn.) (G.92); also an *anthelid*, one of the *Pterolocera* spp. (An.2A). Larvae of these species will mostly emerge from their eggs sooner or later without the addition of moisture, but wetting (or just increased humidity) definitely speeds up the process, bringing out the whole batch more easily and uniformly, within one or two days.

It is possible that dew may suffice to cause hatching in some of these cases, under natural conditions outdoors, particularly if the species involved is a feeder upon weeds, or other low plants on the ground (?) (*X. heliacaria* might be an example here). But, in dry jars or other containers indoors, neither dew nor rain enters the picture.

Larvae in rain-hatched eggs are capable of waiting inside the egg, fully ready to hatch, for many days (even weeks in some cases) beyond the day when they *first* became ready to hatch, and will do just that if kept dry. Exactly how long the larvae of these species can remain alive like this I have not yet determined; it undoubtedly varies with the species. Awareness of this peculiarity is a necessity for the successful hatching of any such eggs in captivity. It is most important, however, that moisture NOT to be applied until the young larvae can be seen, fully-developed inside the egg shells, or the eggs (if enclosed in a glass jar) are very likely to develop mould and/or fail to hatch. *More than one* quick soaking (always followed by a slow *drying*) is sometimes required to induce hatching, once the correct time has arrived.

Although I have reared (from the egg) 28 Australian and 7 North American spp. of Geometrinae (Hemitheinae) to date, I have not encountered a single example of rain-hatched eggs in this subfamily.

Some advantages of the rain-hatched egg could be readily imagined for species inhabiting regions where a long dry season is finally broken by the first rains (the *dates* of which are rarely predictable or consistent) of autumn or early winter. If the larvae, ready to hatch, remain inside their eggs (where desiccation is reduced to a minimum) until the arrival of a good rain, the entire habitat then becomes moist (including the air), and their chances for escaping desiccation while still small are greatly increased. This would be all the more important when a species also has strongly-developed first instar dispersal behavior, as it would increase the potential length of the survival-period while the larvae are still wandering. Incidentally, all

species having rain-hatched eggs do *not* show first instar dispersal (nor vice versa), but some of them do.

First instar dispersal: A notable aspect of first instar larval behavior, which I shall refer to here as "first instar dispersal". is typical of a number of South Australian species, particularly in the GEOMETRIDAE, Subfamily Ennominae. I have also observed it in the NOTODONTIDAE (*Sorama biocolor* Walk.), developed to a modest degree, and highly developed in two genera (three species) of the THAUMETOPOEIDAE (examples = *Discophlebia catocalina* and *Oenosandra boisduvalii*). In the case of the GEOMETRIDAE, 14 spp. (13 ennomines and 1 oenochromine), out of the 112 spp. of Australian geometrids I have reared from eggs to date, have shown this behavior developed to a high degree. (It might be expected to crop up in a number of other Australian moth families as well, such as Psychidae and Lymantriidae, etc.). Twelve examples of South Australian geometrids demonstrating first instar larval dispersal are: OENOCHROMINAE—*Arhodia lasiocamparia* Gn. (my G.124); ENNOMINAE—*Boarmia penthearia* Gn. (G.211), *B. suasaria* Gn. (G.78), *Capusa cuculoides* Felder (G.105), *Cleora displicata* Walk. (G.165), *Ectropis excursaria* (Gn.) (G.75), *Stathmorrhopa eribola* (Guest) (G.90), *Gastrinopa xylistis* Lower (G.137), *Melanodes arthracitaria* Gn. (G.161), *Mnesampela fucata* (Felder) (G.109), *Stibaroma melanotoxa* Guest (G.81), and *S. trigramma* Lower (G.104).

Species characterized by first instar dispersal usually have most (or all) of the following features in common:

- (1) The eggs often (but not always) appear "small" for the size of the moth.
- (2) Large numbers of eggs may be deposited (when compared with other members of the same subfamily not having this behavior, or with other adults of similar size); yet these same moths are very often scarce species (or at least not particularly common) in the adult stage. In such species, the (probable) high mortality-rate, during the dispersal period, may, at least in part, explain some of the cases of apparent low numbers of *adults* among certain spp. feeding on abundant (or widespread) foodplants. Two South Australian examples representing this situation fairly well are *Capusa cuculoides* (Fig. 36) and *Melanodes anthracitaria* (Fig. 39.)
- (3) The eggs are usually deposited very securely-glued, and in large masses or other group formations. The fact that the eggs of species having first instar dispersal are usually deposited in large masses or groups implies that some form of early dispersal would almost have to take place, *except* in those cases where the larvae are normally gregarious or at least semi-gregarious (for example the ennomine geometrid, *Mnesampela privata* (Gn.), and some of the thaumetopoeids, such as *Ochrogaster* spp., or the early instars of *Epicoma* and *Trichetra* spp.). There are some good explanations

for first instar dispersal among species having solitary larvae but depositing their eggs in large masses: These spp. often (not always) deposit their egg masses on the trunks or branches of trees, yet their larvae feed upon the leaves (often only the newer growth at the ends of branches). Therefore, the young larvae must crawl (disperse) actively upward and outward from the hatching-site, if they are ever to reach their food supply. Even when the masses are deposited on the foodplant leaves, these larvae would still be highly vulnerable to predation if they did not disperse soon after hatching. (Such species rarely, if ever, represent forms protected by aposematic colors). Under natural conditions the mortality-rate is almost certain to be extremely high during this active dispersal period. Winds could carry many of the young larvae (when dropping on silk) to other trees or shrubs, *not* necessarily always of acceptable foodplant species, and great numbers are probably taken by predators (ants, young spiders, etc.) during their early wanderings.

- (4) These larvae, upon hatching, have a period (usually 2 to 5 days) of almost ceaseless lively wandering, during which time they show marked phototropism, and (depending on the species) are frequently inclined to drop or hang on silken threads. This habit of repeatedly dropping on silk tends to greatly increase the rate of dispersal under natural conditions, as the larvae of most of these species are in trees, thus being readily blown about by any wind or breezes.
- (5) The foodplants of these species are nearly always *trees* (less often large shrubs). If the plant is sclerophyllous, usually only the tender new leaves are eaten; in such cases the larvae often appear to be *restricted* to the new growth and will refuse to eat older (tough) leaves, or will not grow well on them. The latter is by no means invariably true, but it applies more often than not. Three South Australian ennomine examples are *Capusa cuculoides*, *Gastinopa xylistis*, and *Melanodes anthracitaria*; these spp. feed only on the tender new growth of their foodplants if allowed their preference.

I have yet to see a single example of first instar dispersal behavior among the 28 Australian (or 7 North American) spp. of Geometrinac (Hemitheinae) reared from eggs to date. They are, in most cases, *highly* sedentary larvae right from the moment of hatching. Eggs of Geometrinae are usually deposited singly, or (at most) in twos and threes on the foodplant leaves; less often, in *short* curving rows, *small* "stacks", or irregular *small* clusters. Thus, in the Geometrinae, dispersal is usually accomplished entirely *by the female moth during oviposition*. The larvae hatch where they will be feeding, already dispersed, so there is no cause for additional dispersal to take place during first instar.

Species having first instar dispersal behavior can be difficult to start in captivity when rearing is attempted, but generally give no further trouble once they have *settled down* to begin feeding. During the dispersal period these newly-hatched larvae normally refuse to settle down on *any* plant to feed, *whether*

or not the correct foodplant is present. This can cause failure to locate a suitable foodplant, (and thus failure in an attempted rearing), if one does not recognize first instar dispersal behavior. Careful attention to the following suggestions will lead to success with the rearing of these species: (1) Do not draw any firm conclusions as to *which* of the offered plants are supposedly "unsuitable" until *after* the dispersal period is over. (2) Do not fail to provide sheets of tissue or paper towel in the bottoms of all foodplant sample-jars (into which the newly-hatched larvae are placed). This allows the larvae to more readily untangle themselves from their (often) abundant silken threads, on which they may drop frequently, and to more quickly regain footing among the plants whenever they drop on silk, or when they crawl off onto the sides and bottom of the jar (which they will do endlessly). It is imperative that many of the offered leaves reach down to the *bottom* of the jar (contacting the towel), and that other leaves extend higher up in the jar (with ample space between them), in order to allow those larvae that have begun to settle to partially isolate themselves from others still actively crawling; otherwise, the latter will constantly disturb those trying to start feeding, which will in turn set them to wandering all over again! (3) Place their foodplant sample-jars inside a *totally dark* cupboard, at a cool or mild temperature (not over 70 F., if possible). When in a partially lighted situation, their positive phototropism causes them to constantly migrate toward that side of the jar facing the strongest light source, which is also the side on which maximum condensation will occur. They often became trapped in this moisture, and (at the same time) will fail to uniformly scatter through the offered plant samples, thus "missing" many of the samples until it is too late. (Any becoming stuck in condensation are easily lifted off by means of a small watercolor brush, and can be replaced among the plants). The darkened-cupboard-technique, however, overcomes these difficulties with great efficiency. (4) Alternatively, they can be left in a lighted situation *provided* that the jar is regularly (at least 2 or 3 times daily) turned halfway around, thereby forcing the larvae to crawl straight back through the plant samples as they head (again) toward the brightest light. (Eventually they will tire of this, and begin to slow down). Under all circumstances, the piece of paper towel in the bottom is of vital importance. Also, they must be frequently and critically checked during this wandering period, so that *any* impending trouble will be detected early, and necessary preventive action can be

taken. With many newly-hatched larvae, only a few *hours* under wrong conditions can spell the finish of a proposed rearing project.

Due to the condensation problem, it might be imagined that a screen cage (or semi-cage) would be more suitable for starting small larvae, but this is definitely not so in the case of species having first instar dispersal, *unless* the cage is exceptionally well made (absolutely no tiny cracks), is of a relatively small size, and is made from a very fine mesh material (for example, "Nylon Tule", available at 60c per yard in certain Australian department stores). This will prevent the escape of active small larvae, while providing limited ventilation. (Only *limited* ventilation is desirable). Desiccation of larvae and food-plants is a common problem in a well-ventilated cage. They must be kept reasonably cool, and may need to be frequently sprayed with a fine water-mist under some conditions. Such problems do not arise when using the *closed-jar* technique for starting small larvae (McFarland, 1964, 1965; ref. in preceding paper). Larvae of even the most disease-prone species seem to be amazingly disease-resistant when small (first and second instars±), and are able to tolerate much higher humidity then. By about third instar they are usually ready to transfer from jars to partially ventilated cages, *without* any risk of loss through escape or desiccation.

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NEW FOOD PLANT FOR *DARAPSA PHOLUS* (CRAMER) (SPHINGIDAE)

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TIETZ (1972) listed the following plants for *Darapsa pholus*:
Kalmia angustifolia, *Nyssa sylvatica*, *Rhododendron nudiflora*,
Rhododendron viscosa, *Tradescantia virginiana*, *Viburnum dentatum*,
Viburnum lentago, *Viburnum opulus*.

These records were taken from Beutenmüller (1895), Morris (1862), Harris (1839), J. E. Smith (1779) and others (Eliot and Soule, 1902; Fernald, 1886; Baynes-Reed, 1881). I myself checked additionally the following: Forbes (1948), Holland (1903), Rothschild and Jordan (1903), Clemens (1859), Fernald (1886, re-checked), Draudt in Seitz (1931) and Hodges (1971). The food plants for *D. pholus* mentioned in these publications are the following: Forbes: *Azalea*, *Viburnum* and "reported from other food plants, probably in error for *D. myron* and *cnotus*"; Holland: *Viburnum*, *Azalea*; Rothschild and Jordan: same as those of *Ampeloea myron* (*Ampelopsis*, *Vitis*) which is certainly in error; Clemens: *Azalea nudiflora*; Fernald: *Ampelopsis quinquefolia*, *Viburnum lentago*, *Viburnum dentatum*, *Viburnum opulus*, *Nyssa multiflora*, *Azalea viscosa*, *Azalea nudiflora* (it seems that the error concerning *Ampelopsis* originated with Fernald); Draudt in Seitz: *Ampelopsis*, *Vitis* (probably on the authority of Rothschild and Jordan); Hodges: *Azalea*, *Viburnum* species.

Tietz (1972) also gave *Viburnum* as a food plant for *D. myron* besides *Ampelopsis* and *Vitis*. Hodges (1971) too mentioned *Viburnum* for *D. myron* and it may be that the erroneous record of *Ampelopsis* and *Vitis* for *D. pholus* was created in a kind of exchange between food plants of *myron* and *pholus*. I did not check in which of the many papers quoted by Tietz for *D. myron* this *Viburnum* record originated.

One plant group, however, has never been mentioned among the food plants of *D. pholus*: *Vaccinium* spp., our common blueberries. During field work in 1971 at Queen's University Biological Station at Chaffey's Locks, Leeds Co., Ontario, we found all

stages of *D. pholus* associated with *Vaccinium* spp. and it is not unreasonable to suppose that *Vaccinium* may be a general food plant for the species, the more so as several *Viburnum* species are also common around Chaffeys Locks but *D. pholus* was not found associated with them. Data for the immatures collected in 1971 are: egg on blueberry at Washburn, Ontario, 25 JULY, hatched and reared successfully on blueberry; third instar larva on blueberry on Snake I. in L. Opinicon, Chaffeys Locks, Ontario, 26 JULY, reared successfully on blueberry; a freshly-emerged, unmated female moth flushed from a blueberry patch at the Station around noon, 8 JULY, eggs infertile.

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THE NOMENCLATURE IN AN IMPORTANT BRITISH CHECK LIST (1972)

PART 1: CORRECTIONS OF FAMILY-GROUP NAMES FOR LEPIDOPTERA (EXCEPT GEOMETRIDAE)

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J. D. BRADLEY, D. S. FLETCHER AND P. E. S. WHALLEY prepared a manuscript on Lepidoptera for the second (revised) edition of 'Kloet and Hincks'. This has been published on 29th December, 1972 as Part 2 of the series entitled traditionally 'A Check List of British Insects'.

Unfortunately, the very laborious and modern catalogue of British Lepidoptera as presented now by the Royal Entomological Society of London does not fulfill expectations in some respects of the nomenclature used.

As to the family-group taxa, one finds occasionally an offense against the legalized formation of their names: Family no. 50 is wrongly named '*Endromidae*' (endromis, -idos), instead of '*Endromididae*', in the new catalogue. Later, the family no. 38 includes a subfamily '*Evergestinae*', misspelled by the authors as '*Evergestiinae*'. In other cases, family-group names ending on -stominae are given: '*Cerostominae*' (in the family no. 23) and '*Enicostominae*' (in the family no. 28). Although both subfamilies are called correctly '*Plutellinae*' and '*Depressariinae*' respectively, and although the genera *Cerostoma* and *Enicostoma* have been replaced as junior synonyms by *Plutella* and *Depressaria* respectively, the above family-group names should be referred to as '*Cerostomatinae*' and '*Enicostomatinae*'. An additional case—the family-group name '*Cemiostominae*'—is dealt with in the following paragraphs.

The families no. 11, 15, 17, 44, 52, 59, and 61 (the numbers correspond to the classification adopted actually by Bradley, Fletcher and Whalley) and their nomenclature receive a special attention in the discussions below.

No. 11. *Limacodidae*, type-genus (familiotype) *Cochlidium* Huebner, 1822. The oldest valid name of this genus being *Apoda* Haworth, 1809, family-group names *Limacodidae* and *Cochliidiidae* fall to the ground in favor of *Apodidae*.

No. 15. *Lyoneetiidae*, comprising two subfamilies: *Lyoneetiinae* and '*Cemiostominae*' (i.e. *Cemiostomatinae*). The latter is based on *Cemiostoma* Zeller, 1848, a synonym of *Leucoptera* Huebner, 1825. *Cemiostomatinae* must, therefore, be put aside in favor of *Leucopterinae*.

No. 17. *Gracillariidae*, type-genus (familiotype) *Gracillaria* Haworth, 1828, a genus which is now considered as congeneric (despite of its status of a separate subgenus) with *Caloptilia* Huebner, 1825. The well-known family-group name *Gracillariidae* must, therefore, be replaced by *Caloptiliidae*. The names of two subfamilies included are similarly to be corrected: *Caloptiliinae* (instead of *Gracillariinae*) and *Phyllonorycterinae* (based on *Phyllonorycter* Huebner, 1822; instead of *Lithocolletinae*).

No. 44. *Nemeobiidae*, type-genus (familiotype) *Nemeobius* Stephens, 1827. For reasons of priority, *Nemeobius* has been replaced by *Hamearis* Huebner, 1819, a name which is today universally in use for the genus typified by *Papilio lucina* Linnaeus, 1758. The family-group name *Riodinidae* is based on *Riodina* Westwood, type-genus of *Riodininae* which constitute the typical subfamily of *Riodinidae*. *Hamearis* Huebner, on the other hand, became type-genus of another subfamily, namely *Nemeobiinae*, now to be suppressed in favor of *Hamearinae*, nom. nov.

No. 52. *Thyatiridae*, type-genus (familiotype) *Cymatophora* Treitschke, 1825 (nec Huebner, 1812!) which has been considered for many past decades as a synonym of *Tethea* Ochsenheimer, 1816. The corresponding family-group name would be *Tetheidae*. If, however, the genus *Cymatophora* Treitschke, 1825 will prove definitely to have the same type-species as *Achlya* Billberg, 1820, and later if *Achlya*, *Tethea* and *Polyploca* Huebner, 1821 are all recognized to be independent genera, a change of the family-group name would result (*Achlyidae*, instead of *Tetheidae*).

No. 59. *Ctenuchidae*, type-genus (familiotype) *Ctenucha* Kirby, 1837. All of the species enumerated represent immigrants to Britain and belong to the subfamilies *Euchromiinae* and *Syntomidinae* respectively, the latter being named wrongly, by the authors, '*Syntominae*' (*Syntomis* syn + *tomis*, -idos; fem.). The family-group name *Syntomidinae* falls, however, to the ground in favour of *Amatinae* since *Syntomis* Ochsenheimer, 1816 proved to be a junior synonym of *Amata* Fabricius, 1807 (Mag. Insektenk., Illiger, 6, p.289).

No. 61. *Noctuidae*, subfamilies *Chloephorinae* and *Sarothripinae* cannot bear their names any more since the subfamiliotypes *Chloephora* Stephens, 1827 and *Sarothripus* Curtis, 1824 became in the meantime junior synonyms of *Pseudoips* Huebner, 1822 and *Nycteola* Huebner, 1822 respectively. Accordingly, alternative names must be introduced for the two subfamilies: *Pseudoipinae* and *Nycteolinae*.

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A NAME FOR
GLAUCOPSYCHE LYGDAMUS BEHRII AUCT.,
NOT EDWARDS 1862

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F. M. Brown (Trans. amer. ent. Soc. 96:415-417:1970) has shown that the name *Lycaena behrii* Edwards 1862 pertains to *Glaucopsyche xerces* (Boisduval) 1852 and not to *G. lygdamus* (Doubleday) 1842. The way in which the name *behrii* came to be used erroneously for a moiety of the *lygdamus*-complex is discussed by Brown and need not be repeated here.

The misidentification of the central-coastal Californian subspecies of *lygdamus* as *behrii* has resulted in this familiar insect never having been given a name of its own. The purpose of this paper is to remedy this situation.

Glaucopsyche lygdamus incognitus Tilden, subsp. nov. Holotype male: Forewing 16.2 mm. Above: Cold light blue, with two iridescent overlays depending on angle at which the insect is viewed: one lavender or pale lilac, the other faintly greenish-blue. Wing veins outlined narrowly by light scales except at vein-ends which are darkened. Borders very dark, narrow (about 1 mm.), slightly wider at forewing apex and extending very narrowly down the forewing costa, and on hind wings to vein Rs.

Below: Pale gray, the wing bases plentifully clothed with pale bluish pubescence. Terminal line dark, complete. Forewing fringes faintly darkened at vein ends. Cell-end bar evident on both front and hind wings. Postbasal spots of hind wings present. Spots of postmedian band black, narrowly ringed with white, those of the forewing a bit larger than those of the hind wing.

Holotype male: Alum Rock Park, Santa Clara County, Calif., March 3, 1940, leg. J. W. Tilden. Type locality: same as above. The holotype is deposited in the collections of the California Academy of Sciences, San Francisco, Calif.

Because this subspecies, though previously unnamed, is well known and represented in most collections, and its identity cannot be in doubt, only a holotype is designated. The name, *incognitus*, unknown, unrecognized, disguised, is given because this insect was called so long by the name of another.

Three other quite similar subspecies of *lygdamus* inhabit regions adjacent to or adjoining the range of *G. l. incognitus*, new subsp. These are *G. l. australis* Grinnell, to the south; *G. l. oro* Scudder, in the Rocky Mountains, and *G. l. columbia*, to the north and east.

P. l. australis averages slightly smaller than *incognitus* (forewing 14-15 mm.) and males are a slightly warmer blue above. Below, the ground color is a deeper gray. The spots of the postmedian band are very prominent on the forewing. Those of the hind wing are small, and often appear as white spots with small dark centers, giving this population a very distinctive appearance. As noted by Grinnell (1917) in the original description, these tendencies, though best marked in southern California, extend as far north as Monterey County.

Skinner (1917) states that Scudder described *oro* from Colorado as being larger than *behrii*, which to Skinner meant the insect here described as *incognitus*. But to Scudder, *behrii* presumably meant Edwards' original concept of *behrii*, which is *xerces* Boisduval. *Oro* averages smaller than most *incognitus*. The males are of a light, nearly sky blue above, and thinly scaled, so that the spots of the macular band can be seen from above. The spots are of medium size, about the same size on both front and hind wings, each outlined in white. The ground color of the underside is brownish gray, darker than that of the other populations under discussion.

When describing *columbia*, Skinner (op. cit.) chose Port Columbia, Washington, as type locality, but included material from "Olympia, Washington; Corfield, Vancouver; and Lake Tahoe, California". He characterized *columbia* as of a deeper blue, larger, the wing texture less delicate, as compared to other subspecies of *lygdamus*, and as having the spots larger than in

"*behri*" (= *incognitus*) but smaller than in *lygdamus*, and the underside lighter than that of *lygdamus*. The name *columbia* is applied at present to populations of *lygdamus* from the Sierra Nevada of California, north at least to southern British Columbia, west of the Rocky Mts. Over this extensive region, the populations of *lygdamus* are by no means homogeneous, and not all agree well with Skinner's description.

I am indebted to F. Martin Brown for his cooperation in connection with this paper.

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JUNONIA AND PRECIS

A CORRECTION

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IN A RECENT PAPER I united the genera *Precis* Huebner and *Junonia* Huebner. I was unaware at that time of an article (de Lesse, 1952) showing conclusively that *Junonia* and *Precis* are both valid genera, the types of which have quite different male genitalia.

It is evident that those species I examined are all members of the genus *Junonia*, and that I did not examine any members of the genus *Precis*. My error was due to my acceptance of two previous but erroneous statements by others, (1) that New World species comprise the genus *Junonia*, that *Precis* consists of Old World species, and (2) that the types of *Junonia* and *Precis* are congeneric. Neither of these statements is correct.

Papilio orithya L. is indeed congeneric with *Papilio lavinia* = *Papilio evarete* Cramer, as I found it to be, but it is a member of *Junonia*, not *Precis*.

That portion of my previous paper, dealing with the status of the species of Buckeye Butterflies of western North America is not affected by this correction.

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A CLARIFICATION OF
THE FLIGHT PERIODS OF
SEVERAL SIBLING SPECIES OF MOTHS

IN OHIO AS INDICATED BY LIGHT TRAPS

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LIGHT TRAPPING HAS BEEN AND WILL REMAIN a good method of determining the flight activity, relative abundance, and seasonal fluctuations for many species of insects. Banerjee (1967) used light traps to determine the periods of activity for several species of crambid moths. Selman and Barton (1972) utilized light traps in Arkansas to study the seasonal trends and relative abundance of 12 species of Lepidoptera. The United States Department of Agriculture is constantly monitoring insect population fluctuations by means of light traps, and it is from their traps at Wooster, Ohio that data for this paper were collected.

Each species of moth discussed herein has one or more sibling species associated with it in Ohio and this has caused records for them to be confused in the past. The purpose of this paper is twofold: first, to clarify the seasonal activity of these species; and, second, to report the occurrence of some of these species in Ohio where there are no published records for them. When he stated that it was almost impossible to sift out records for the (*Apantesis*) *nais* complex in Florida, Kimball (1965) echoed my feelings that it would be almost impossible to sort out Ohio records for all of the species presented in this paper.

The graphs (Figs. 1-4) present the weekly catches for each species of moth. The dates correspond to the last day of that week. These curves are presumed to indicate the flight periods and relative abundance to some extent. By plotting weekly catches, some short-term variations in trap counts caused by weather variables should have been overcome.

Fig. 1 *Halysidota*
tessellaris
harrisii

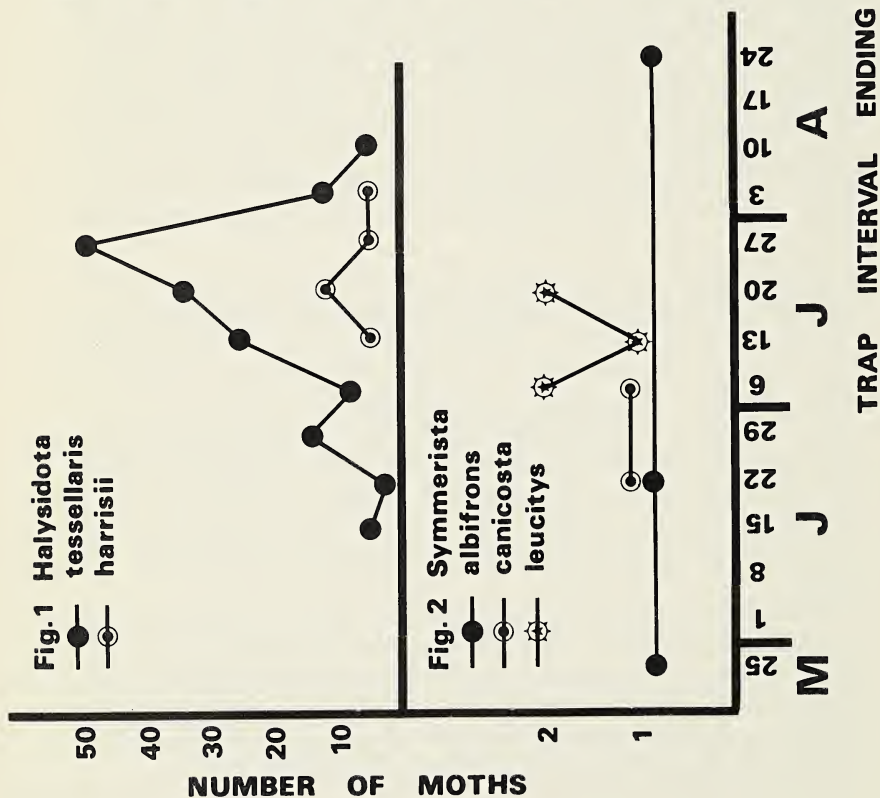


Fig. 2 *Symmerista*
albifrons
canicosta
leucitys

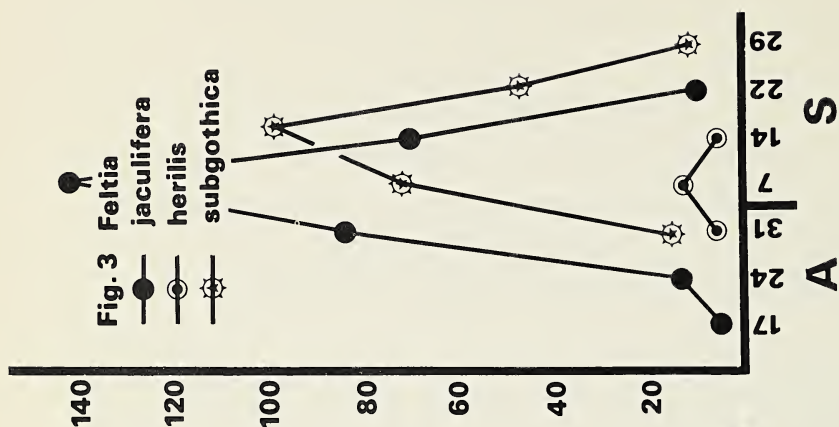
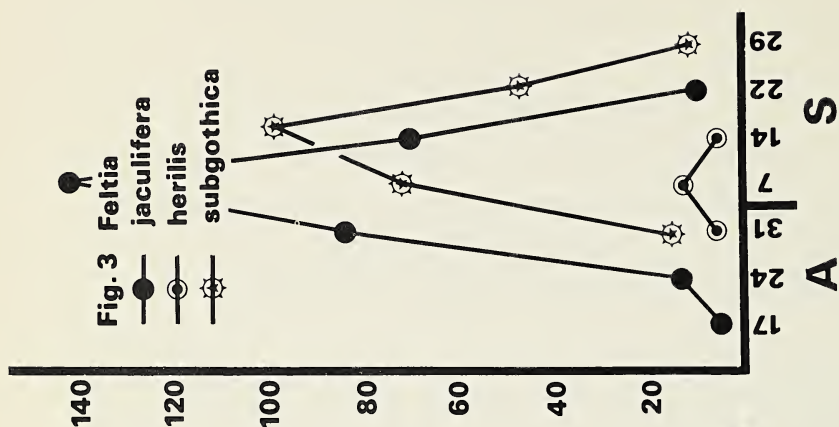


Fig. 3 *Feltia*
jaculifera
herilis
subgothica



METHODS AND MATERIALS

Three blacklight traps of the type recommended by the Entomological Society of America for general insect surveys (Anonymous, 1966) were used in this study. One trap with a 15-w fluorescent blacklight lamp was located in an open, wooded area at the Ohio Agricultural Research and Development Center about one mile southeast from the center of Wooster, Ohio; another with a 15-w lamp was located in a residential area about two miles northwest of Wooster; and, the third, with a 60-w blacklight lamp, was in the center of a field crop area (planted in corn, soybeans, strawberries, and sorghum and bordered by wild cherry, apple, plum and peach trees) on route 250 about two miles east of the Ohio Agricultural Research and Development Center at Wooster. The collecting containers were emptied daily, a preliminary check was made for economically important species, and the moths were placed in 70% ethyl alcohol until they could be examined. The traps were operated throughout 1972.

The male genitalia of every moth presented herein was examined to ascertain its specific identity. Some species (e.g. *Apantesis* spp.) could be recognized without dissection of the genitalia by simply removing the scales from the caudal end and examining the apical processes of the valvae. Others (e.g. *Symmerista* spp.) had to be macerated in KOH and dissected before their specific status could be ascertained. Female genitalia were not examined.

RESULTS AND DISCUSSION

Halysidota tessellaris Abbot and Smith and *H. harrisii* Walsh. —Until recently there had been much confusion on the status of these two species. Tietz (1952) believed that *harrisii* was simply a variety of *tessellaris*. His records for *tessellaris* in Pennsylvania are surely a mixture of both species because Tietz recognized that there was a slight morphological difference between the larvae of *tessellaris* and *harrisii*, and had collected both types.

Interestingly, Walsh (1864) described *harrisii* as a form of *tessellaris* on the basis of the difference in the larvae, but could find no difference in the imago stage of the two. Grote (1882) also believed *harrisii* to be a dimorphic larval variety of *tessellaris*. Nine years later Dyar (1891) stated why he believed them to be separate species. Thus the confusion continued

until Forbes (1960) described distinct morphological differences in the imago and concluded them to be distinct species.

H. tessellaris was first caught during the week ending June 15 (Fig. 1). Their numbers steadily increased until July 27 and then there was a sharp decline until the last specimen was taken on Aug. 10. *H. harrisii* was not as numerous as *tessellaris*. It was not until July 13 that the first specimens appeared at the trap (Fig. 1). The following week *harrisii* reached its peak activity. No more *harrisii* were trapped after Aug. 3. This is the first published record of *harrisii* for Ohio; however, *tessellaris* has been collected in Seneca (Henninger, 1910), Montgomery (Pilate, 1882), and Pickaway (Bales, 1909) Counties, Ohio.

Apantesis nais (Drury) and *A. phalerata* (Harris).—There have been a number of names given to these two species. As late as 1952, Tietz, working in Pennsylvania, considered *A. vittata* and *A. radians* as distinct species, but it is now known they are synonyms of either *nais* or *phalerata*. He did state that these species were highly variable and that they could be color varieties of a few species. Bales (1909), in his list of Lepidoptera taken at Pickaway County, Ohio, recorded only *A. vittata*; therefore, it is not known whether he collected *nais* or *phalerata*. Similarly, other Ohio records for this complex are confused.

The first specimens of *A. nais* and *phalerata* were taken during the week ending May 25 (Fig. 4). Only a few specimens of each species were trapped until August, with both species having peak flights on Aug. 31. The last *phalerata* was taken on Sept. 7, whereas the last *nais* was trapped Sept. 21.

Phragmatobia fuliginosa rubricosa (Harris) and *P. lineata* Newman and Donahue.—Until Donahue and Newman (1966) described *P. lineata* as a new species, records for it were intermixed with either *rubricosa* or *P. assimilians*. Obviously Tietz (1952) recognized only one species, *rubricosa*; however, his records probably include a mixture of both *lineata* and *rubricosa* since both are now known to occur in Pennsylvania.

During the week of May 11, the first *P. rubricosa* was trapped (Fig. 4) but then no more were taken until July 20. Flight activity was at its peak on July 27, after which their numbers began to decline until the last specimens were taken on Aug. 17. This is the first published record of *rubricosa* for Ohio. Donahue and Newman (1966) did not report the distribution of *rubricosa* as including Ohio; however, they stated that it probably occurs here. Since they include many records for this species in adjacent states, *rubricosa* will probably be found to be more common when more extensive light trapping is done in Ohio.

P. lineata was found to be less common than *rubricosa*. The first specimen was caught during the week of July 6, and the last one appeared on July 27, with activity at its greatest during the second week of July (Fig. 4). It should be noted that one might expect to collect *lineata* later into the year, since the one Ohio record of this species was taken on Sept. 8 (Donahue and Newman, 1966).

Symmerista albifrons (Abbott and Smith), *S. canicosta* Franclemont, and *S. leucitys* Franclemont.—Until Franclemont (1946) resolved this complex, *canicosta* and *leucitys* were misidentified as *albifrons*. *S. albifrons* has reportedly been taken in Ohio on numerous occasions; however, the following data constitutes the first published record of *canicosta* and *leucitys*.

Although there were only a few specimens of these three species trapped, their flight activities concur with Franclemont's (in Forbes, 1948) findings. He stated that *albifrons* is active during May to June and in August for New York and neighboring states. The graph (Fig. 2) indicates this to be the case for Ohio; however, only one specimen was taken in May, one in June, and one in August. Further, Franclemont says that *canicosta* flies during June and July. The two specimens of *canicosta* reported herein were taken during the weeks ending June 22 and July 6 (Fig. 2).

More specimens of *leucitys* were taken than either of the other species of *Symmerista*, and they were all taken in July (Fig. 2). Franclemont reported *leucitys*' flight activity as mid-June to July (in Forbes, 1948).

Feltia subgothica Haworth, *F. herilis* Grote, and *F. jaculifera* Guenee.—Past records for this complex also need further verification. Tietz' (1952) records for Pennsylvania did not include *herilis*, and he seems to have used the name *ducens* for *subgothica* and *subgothica* for *jaculifera*. Interestingly, Turner (1920), in his light trapping study of Maryland Lepidoptera, must have realized the uncertainty of this group as his Table I lists 57 separate species, but simply reported all of his 411 specimens of this group as *Feltia* spp. Also, Stanley and Bennett (1965), in reporting on the seasonal abundance of 13 species of moths in Tennessee, state that *F. ducens* and *F. subgothica* are difficult to separate and since their occurrence is similar they are reported as one species.

The most common species in this complex was *F. jaculifera*. The first *jaculifera* was taken during the week of Aug. 17 (Fig.

3), and its numbers then increased rapidly until activity was at its height on Sept. 7. No more specimens were trapped after Sept. 22.

About two weeks after *jaculifera* appeared, the first *F. subgothica* was caught. Thereafter, flight activity increased until Sept. 14, and then declined until the last specimens were taken during the week ending Sept. 29 (Fig. 3).

Only 20 specimens of *F. herilis* were trapped. These were distributed in such a manner as to form an almost symmetrical curve (Fig. 3) having its beginning on Aug. 31, peak on Sept. 7, and ending on Sept. 14.

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LIFESPAN OF BUTTERFLIES

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Abstract. Expected lifespan was found from survival rates estimated from mark-recapture experiments of 26 species. Expected lifespan is only about 7-12 days in temperate species without adult diapause or hibernation; females usually live slightly longer than males. Hot weather decreased lifespan of three species. Some tropical species live several months. Long life of up to 8 months can occur in temperate species hibernating as adults. Some temperate and tropical species aestivate for several months as adults in dry periods.

INTRODUCTION

LIFESPAN IS A CRUCIAL PARAMETER for the survival of butterflies. This paper shows that, except for some tropical species and species with adult aestivation or hibernation, expected (average) lifespan is only about 7-12 days (of course some individuals die sooner or live much longer). Because the preoviposition period of females is usually 3-8 days (Scott, 1973a), females therefore have an average of only about 4-9 days to oviposit, including days of bad weather.

METHODS

This paper is based on my mark-recapture studies of eleven species, details of which will be reported elsewhere, and those of previous authors. Lifespan is estimated from survival rates found from mark-recapture experiments using either the method of Fisher and Ford (1947) or of Jolly (1966). Single overall survival-rate estimates were obtained from daily survival estimates provided by Jolly's method by using method 1 of Scott (1973b). All of the studies using the Fisher-Ford and Jolly methods assumed a survival rate independent of age, but survival rate may actually decrease somewhat with age. Since the maximum lifespan of most species studied is three or more times the expected lifespan (Frohawk, 1934; this paper), the assumption of independence may be reasonable.

RESULTS

Species without adult diapause or hibernation. Since butter-

flies when first marked are almost always post-teneral (because teneral individuals seldom fly), the teneral period of about a day must be added to the lifespan in Table 1. With this teneral period added, expected lifespan is about 7-12 days for species without adult diapause or hibernation. The only known exceptions are tropical species: *Heliconius* lives up to six months, several Ithomiinae (*Ithomia pellucida* and *Hypothyris euclea*) live up to four months (Lawrence Gilbert, oral communication); *Morpho* and *Battus* live several months. The short lifespan means that the mating system must be efficient to minimize waste of time, and that most females die before laying all their eggs. *Parnassius*, *Parides*, *Heliconius*, and *Danaus* are probably unpalatable to vertebrates, but this has not increased their lifespan; *Heliconius* may live longer due to pollen feeding as adults (Gilbert, 1972).

Affect of weather on lifespan. In *Amblyscirtes simius* and *Neominois ridingsi* the expected lifespan was less in 1970 than 1969 apparently because 1970 was hot. The hot weather probably increased mortality although it could have increased emigration, and therefore lowered the calculated survival rate, a small amount. The 1970 expected lifespan of *L. arota* is very low compared to that of *L. xanthoides* also probably because of very hot weather.

Lifespan of males versus females. There seems to be little difference between the expected lifespan of males and females in *Parides*, *Neominois*, *Heliconius*, *Hypolimnas*, and *Precis* (the female *Precis* recorded rate is lower probably because of greater emigration). In *Lysandra coridon*, males live slightly longer than females. In *Ascia*, *Hypaurotis*, *Lycaena arota*, *L. xanthoides*, *Lysandra bellargus*, *Argynnis paphia*, and *Amblyscirtes*, females live longer than males, much longer in three species. In several Satyrinae, females live several months longer than males (see adult diapause below). Because females disperse farther and usually faster than males, their emigration would tend to lower survival rate more than in males, which may mean that in some of the above species which appear to have similar lifespans, females may actually live longer. Therefore in general females live slightly longer than males. This may occur because males can fulfill their function (mating) rapidly, whereas the location of suitable larval host and the maturation of eggs are more time-consuming processes. Also the more conspicuous mate-locating behavior of males may expose them

to more predation. Longer lifespan of females may cause selection on males to be mostly sexual selection, while selection on females is more to survive predation.

Hibernation. Some temperate species hibernate: *Gonepteryx rhamni*, *G. cleopatra*, *Danaus plexippus*, *Anaea andria*, *Polygonia* spp., *Aglais urticae*, *Inachis io*, *Nymphalis* spp., *Vanessa atalanta* (Ford, 1945; Valetta, 1970; Klots, 1951). *G. cleopatra* and some *Polygonia* mate in fall and oviposit in spring (Valetta, 1970; Jon Pelham, oral communication); the other species mate in spring. All of these species hibernate with immature ovaries except perhaps *Anaea* (Baker, 1969).

Adult diapause. Some species have adult diapause in areas with a dry season. *Maniola jurtina* on islands west of Italy mates, males die, then females aestivate two months then oviposit (Scali, 1971). *Brintesia circe* (both are Satyrinae) also does this (Verity, 1919). In the dry season in Costa Rica, *Eurema daira* and *Hamadryas* spp. live several months (Paul Opler, oral communication). *Eurema daira*, *Mechanitis isthmia*, and many other species have immature ovaries during the dry season in Costa Rica (Orley Taylor, written communication). *Coenonympha tullia* may live many weeks in the dry season in California (Lawrence Gilbert, oral communication). Long adult life may evolve if larval mortality is greater than adult mortality over the same period.

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TABLE 1. Survival rates and expected lifespans in days ($= -1/\ln S$, where S is survival rate, Cook et al., 1967) of butterflies based on mark-recapture experiments of species without adult diapause or hibernation.

d- accurate, due almost entirely to death rate

+ - should be increased slightly due to a small amount of emigration

° - should be greatly increased due to large amount of emigration

SPECIES	SURVIVAL RATE	EXPECTED LIFESPAN	SOURCE
<i>Parnassius phoebus</i> ♂♂	.842	5.8+	Scott, this study
<i>Parides neophilus</i> ♂♂	.83	5.4°	Cook et al. 1971
" ♀♀	.76	3.6°	"
<i>Parides anchises</i> ♂♂	.76	3.6°	"
<i>Ascia monuste</i> ♂♂		5-6 days	Nielsen, 1961
" ♀♀		7-10 days	"
<i>Euchloe ausonides</i> ♂♂	.835	5.5+	Scott, this study
<i>Neominois ridingsii</i> 1969 ♂♂	.915	11.2d	"
" 1970 ♂♂	.807	4.7d	"
" 1970 ♀♀	.813	4.8d	"
<i>Maniola jurtina</i> , colony of 500 ♂♀	.75	3.5d	Dowdeswell et al 1949
" colony of 3000, ♂♀	.93	13.8d	"
" " 15000 ♂♀	.89	8.6d	"
<i>Parage megera</i> ♂♀	.789	4.2+	Parr et al 1968
<i>Coenonympha tullia</i> ♂♀	.70	2.8d	Turner 1963
<i>Morpho</i> spp.		several months	Young 1971
<i>Heliconius erato</i> ♂♂	.997	several mos.	Turner 1971
" ♀♀	.985	"	"
<i>Danaus chrysippus</i> ♂♀	.775	3.9°	Edmunds 1969
<i>Hypolimnus misippus</i> ♂♂	.649	2.3°	"
" 1965 ♀♀	.650	2.3°	"
" 1966 ♀♀	.665	2.4°	"
<i>Argynnis paphia</i> ♂♂		about 9 days	Magnus 1954a
" ♀♀		about 14 days	"

TABLE 1 (continued)

SPECIES	SURVIVAL RATE	EXPECTED LIFESPAN	SOURCE
<i>Poladryas arachne</i> ♂♂	.794	4.3+	Scott, this study
<i>Precis coenia</i> native males	.878	7.8+	"
bred and released males	.912	10.9+	"
" females	.897	9.2+	"
<i>Hypaurotis chrysalus</i> ♂♂	.803	4.6d	"
" ♀♀	.888	8.4d	"
<i>Lycaena arota</i> ♂♂	.763	3.7+	"
" ♀♀	.790	4.2+	"
<i>Lycaena xanthoides</i> ♂♂	.893	8.9d	"
" ♀♀	.932	14.2d	"
<i>Polyommatus icarus</i> ♂♀	.744	3.4+	"
" ♂♀	.83	5.4d	Dowdeswell, et al 1940
<i>Lysandra bellargus</i> June ♂♂	.79	4.2d	Davis, et al 1958
" September ♂♂	.90	9.5d	"
" June ♀♀	.92	12.0d	"
" September ♀♀	.91	10.6d	"
<i>Lysandra coridon</i> ♂♂	.86	6.6d	"
" ♀♀	.81	4.7d	"
<i>Hesperia pahaska</i> ♂♂	.741	3.3+	Scott, this study
<i>Amblyscirtes simius</i> 1969 ♂♂	.865	6.9d	"
" 1970 ♂♂	.822	5.1d	"
" 1970 ♀♀	.844	5.8d	"
<i>Ochlodes snowi</i> ♂♂	.875	4.1+	"
<i>Battus bellus</i>	several months		Young, 1972

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ALTITUDINAL MIGRATION OF BUTTERFLIES IN THE CENTRAL SIERRA NEVADA

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A SUBSTANTIAL PORTION of the butterfly fauna of the eastern United States participates in a general northward migration in late summer and early autumn, carrying many species up the Atlantic Coastal Plain far to the north of their permanent ranges (Clark and Clark, 1951; Nabokov, 1946; Shapiro, 1966). These species may overwinter successfully in mild years as far north as New York or New England but in severe winters may be exterminated as far south as Georgia. Apart from epigamic "hilltopping" phenomena, western and European collectors have known for many years that "strays" of lowland species frequently turn up at considerable elevations, and the literature is replete with such records, but the significance of this fact has been generally overlooked. Altitudinally inappropriate records have been a source of confusion to workers attempting to interpret western montane butterfly distributions in classical "life zone" fashion. Tilden (1959) lists a number of such species as "widely ranging" (and by implication breeding) across zonal boundaries. Two of these, the Buckeye (*Precis coenia* Hbn., Nymphalidae) and the Checkered White (*Pieris protodice* Bdv. and LeC., Pieridae) regularly move northward on the Atlantic Coastal Plain, often reaching eastern Massachusetts, but their inability to survive most northeastern winters casts some doubt on their adaptation to the similar winters of the mid- to high-elevation Sierra Nevada. Emmel and Emmel (1962) report both occurring commonly throughout the season at Donner Pass, ca. 7000 ft., Placer County. This Sierran locality is notorious for the severity of its winters. *P. coenia* is recorded up to lower Canadian Zone (8000 ft.) and *P. protodice* through Canadian (to 9000 ft.) in Yosemite by Garth and Tilden (1963). They consider *protodice* taken above 7000 feet to be strays.

In 1972, I collected intensively at sea level in the Sacramento Valley and at approximately 5000 and 7000 feet along Interstate 80 through the central Sierras in Nevada County, obtaining phenological and ecological data on butterflies and skippers. Certain inconsistencies with published Sierran data were immediately apparent; among these were the absences of *P. coenia* and *P. protodice* from apparently suitable habitats at both elevations in the mountains, and also of *Strymon melinus pudica* H. Edw., recorded by Garth and Tilden to 7000 feet and by Emmel and Emmel as common most of the season at Donner Pass in 1960. All of these species were eventually taken under circumstances suggesting strongly that their presence in 1972 was dependent on migration from lower elevations. All were abundant in the Sacramento Valley and foothills throughout the 1972 season.

Collecting was done in a great variety of habitats around Lake Spaulding, the Marin-Sierra Boy Scout Camp, and the intersection of I-80 with California Route 20, elevations near 5000 feet, and at Castle Peak-Boreal Ridge, along the Pacific Crest Trail, near 7000 feet. Both study areas supported very diverse montane butterfly faunas, producing 63 and 71 species, respectively. Collections were made weekly from 17 May to 27 October. In the course of these collections, two new altitudinal records were established for skippers (Hesperiidae) abundant in the Sacramento Valley, *Hylephila phyleus* Drury and *Lerodea eufala* Edw., and three specimens of the lowland species *Lycaena helloides* Bdv. (Lycaenidae) were taken. Tilden (1959) lists this species as one of the "widely ranging," non-zonal forms; Garth and Tilden (1963) record it through Transition Zone ("believed to be primarily a dweller of the lowlands, but occasional specimens have been found at higher elevations").

The 1972 records follow:

P. coenia: 5000', 1 ♂ vii.28; 1 ♀ x.23. 7000', 1 ♀ x.4.

L. helloides: 5000', 1 ♂ vi.13; 1 ♀ vii.28. 7000', 1 ♀ vii.17.

S. melinus pudica: 7000', 1 ♂ ix.29.

P. protodice: 5000', 1 ♀ x.4. 7000', 2 ♂ 1 ♀ ix.7.

H. phyleus: 5000', 1 ♀ ix.29.

L. eufala: 5000', 1 ♂ viii.31.

Of these, the vii.28 *helloides* and x.4 *protodice* were extremely fresh and the vi.13 *helloides* and three ix.7 *protodice* and x.4 *coenia* very worn. The sexes and behavior of the insects militate against their presence being due to "hilltopping" (Shields, 1967).

From these records, it seems unlikely that any of these species overwintered at 5000 ft. or higher in 1971-72. The winter of 1971-72 was one of the driest of modern record in California (Dickson, 1972 a,b; Taubensee, 1972 a,b; Wagner, 1972). It is conceivable that poor snow pack (cf. U.S. Dept. of Commerce, 1972) failed to provide adequate insulation for overwintering individuals of sensitive species, a common occurrence in the northeastern U.S. (Shapiro, unpublished). However, it is not necessary to postulate successful overwintering to account for sizeable populations at high elevations, if migrants arrive early enough in the year from lower elevations and are able to breed successfully. This failed to occur in 1972. Emmel and Emmel recorded *P. coenia* common all the 1960 season at Donner Pass, beginning the second day of observation (vi.18), and *S. melinus* common from vii.7. (Emmel and Emmel's records of *P. protodice* are not altogether trustworthy as they do not record *P. occidentalis* Reakirt, a very similar species which is a common resident at both Donner Pass and Castle Peak.) (Some previous records of *L. helloides* in the Sierra may be based on misidentifications of *L. nivalis* Bdv., a montane species common at 7000 ft. and occasional at 5000.) In 1973, *P. coenia* and *S. melinus* did not reach Castle Peak, at the same elevation as Donner Pass, until so late in the year that morning frosts were general and cloudiness persistent. Similarly, in "bad" migration years in the northeast, *P. coenia* does not reach Philadelphia until early October, too late to reproduce successfully.

Hylephila phyleus is a regular migrant in the northeast, overwintering about one in every ten years at Philadelphia. In the Sierra its usual host plant, Bermuda grass (*Cynodon dactylon* (L.) Pers.), is absent but other possible hosts may be available. *Lerodea eufala* feeds in the Sacramento Valley on the grasses *Echinochloa crus-galli* (L.) Beauv. and *Setaria* and *Sorghum* spp. None of these occurs above the foothills, except perhaps in highly disturbed sites. *L. eufala*, formerly confined to southeastern California, has greatly extended its range northward in the past fifty years and may still be spreading northward and up-slope in and around the Central Valley; available records do not make clear whether it crossed the Tehachapi/Transverse Ranges or the Coast Ranges, but it obviously has considerable potential for dispersal.

Colias eurytheme Bdv. (Pieridae) is an ubiquitous species in California, from sea level to the Arctic-Alpine Zone. In the northeast, *C. eurytheme* has been permanently established on

the Piedmont and Coastal Plain north to Boston since the early 1930's, but it still overwinters only sporadically on the high plateaus of central New York and in the mountains of north-eastern New York and New England. At Ithaca, New York, the very spotty overwintered butterflies are supplemented by a surge of worn, summer-phenotype immigrants in May or June every year. A similar phenomenon is to be expected in the Sierra. *C. eurytheme* is abundant in the Sacramento Valley from early March to late November or early December. At 5000 ft., a few *eurytheme* were flying as early as v.17, but at 7000 ft. none were seen before vi.30. At both elevations, the population peaked very conspicuously in late September and October. At 5000 ft. the first few taken were a mixture of fresh and worn individuals, but at 7000 ft. there were hardly any fresh *eurytheme* before late July-early August.

In the northeast, the European Cabbage Butterfly, *Pieris rapae* L. (Pieridae), overwinters everywhere. This is probably true in the Sierra as well, but there is evidence that its populations are bolstered by immigrants from lower elevations. Apparent fly-ups of *P. rapae* in worn condition were taken at 5000 ft., v.17, and 7000 ft., v.31. Fresh butterflies of the overwintering phenotype were recorded at 5000 ft. on vii.7 and at 7000 ft., on vi.30, vii.7, and vii.14. The first fresh summer phenotype *rapae* were taken at both elevations on vii.28—just a bit early to be the progeny of a brood eclosing at the beginning of July. The spring brood of *P. rapae* begins flying in the Valley in late February and the second flight begins in late April. The immigrant *rapae* taken in the mountains in May were of the early summer phenotypes prevalent in the Valley at that time.

ACKNOWLEDGMENTS

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EARLY STAGES AND BIOLOGY OF *PHYCIODES ORSEIS* (NYMPHALIDAE)

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THE PURPOSE OF THIS PAPER is to describe the early stages of *Phyciodes orseis*, and to determine its taxonomic relationship with other *Phyciodes*.

A female *P. orseis* from near Glenbrook, Douglas County, Nevada, was confined in 1972 with three suspected composite species. She laid a cluster of about 35 eggs on a *Cirsium* leaf. The larvae were raised to adults on various *Cirsium* species including *C. vulgare*. The larvae ate all *Cirsium* species tried which have thin green mostly glabrous leaves, but they did not eat several Colorado species with thick leaves and woolly white pubescence. Total time from laying of eggs to emergence of adults averaged 51 days for males and 58 days for females (indoors). Pupal stage lasted an average of 10 days for males, 13 days for females. Both sexes emerged in morning.

Egg. Shape as in other *Phyciodes*; barrel shaped, with flattened base and rounded top. Upper sides with about 22 vertical ribs, connected by tiny crossbars. Lower half with many small depressions of the diameter of or slightly less than width between ribs. Top with many polygonal cells. Micropyle with a circular area surrounded by about 9 (9, 9, and 10 in three eggs) cells (Fig. 2). Second and third cell rank progressively larger than rosette cells.

First Instar. Head uniform sclerotic brown, with darker areas internal to ocelli. Body cream. Suranal plate very weakly sclerotized, with a small dark spot (Fig. 3).

Second Instar. Head and body same color as first instar. Dorsal scoli have about 12 setae, scoli below spiracles have about 6 setae. Length of anal scoli about three times basal diameter. Suranal plate very lightly sclerotized.

Third to Sixth Instar. Head capsule black with two cream colored areas: a circular area around a dorsal seta and a stripe on dorsum, extending posteriorly and slightly laterally, length about three times width. The circle and stripe are nearly or partially connected in third instar, separated by diameter of circle in later instars. Some fifth and sixth instar larvae have three lightly sclerotized triangular areas on frontoclypeus (Fig. 1), most have this structure entirely black. Intermediate sized larvae have the color pattern shown in Fig. 1: a mid-dorsal dark line, then a white (sometimes ochre) line; then a maroon-black broad area surrounding subdorsal and supraspiracular scoli (with small whitish spots surrounding tiny setae);

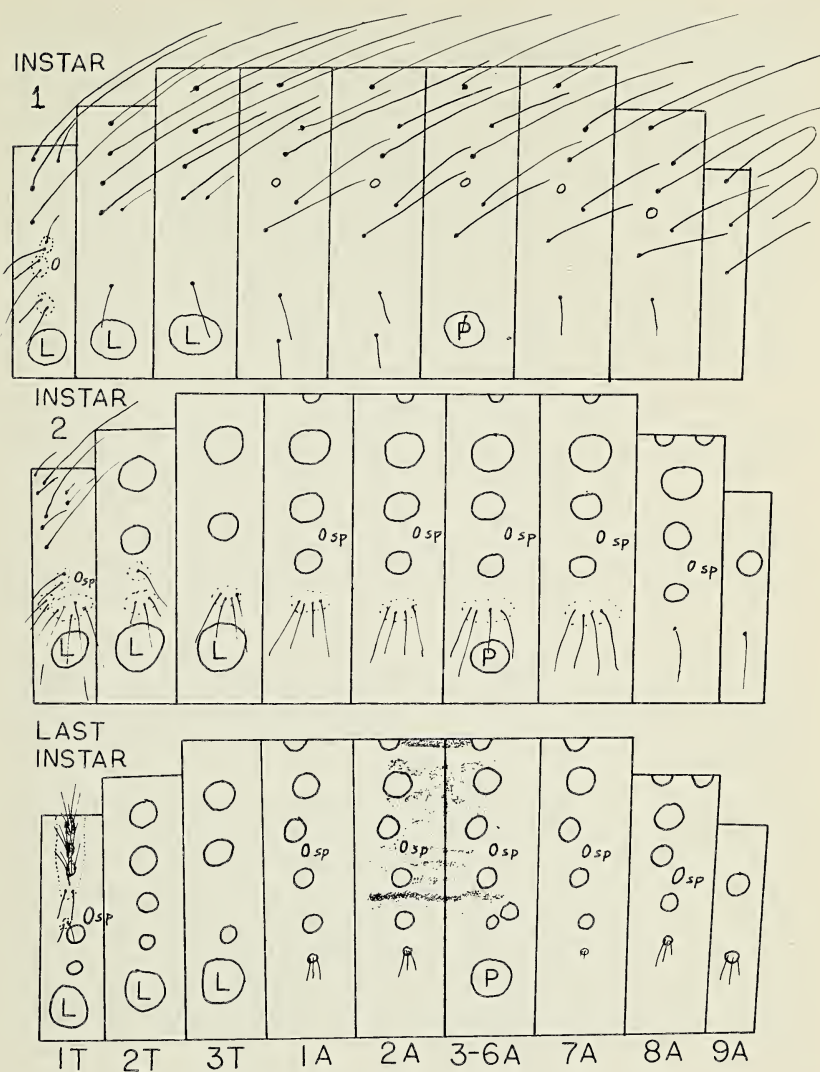


Fig. 1.—Setal pattern of *P. orseis*. Dotted lines surround raised areas of first and second instars, and surround sclerites of mature larva. Circles are scoli, legs (L), or prolegs (P). Color pattern of intermediate sized larva is drawn onto mature larvae setal pattern.

then a white to yellowish white zone surrounding spiracles and lateral scoli with dingy maroon areas inside this whitish area presenting the appearance of several whitish stripes, one just above spiracles and the other running through lateral scoli (there are whitish circular areas surrounding spiracles); a dark dingy maroon stripe below lateral scoli; ventral surface light dingy maroon. In 5-6 instar the maroon-black is widespread over the dorsal half of the larva and nearly or almost completely obscures this pattern. Tiny white spots also occur around tiny setae. In intermediate sized larvae the scoli above spiracles are all black, and scoli below spiracles are ochre colored (sometimes the tips of lateral scoli are black); scoli are all mostly black in mature larva. Setae of scoli are dark brown or black. Dorsal scoli of mature larva with about 25 setae, ventral scoli with only about 10. Length of anal scoli of mature larva only about 2 times basal diameter. Suranal plate of mature larva unsclerotized, ochre, with numerous tiny setae. Lateral anal proleg sclerites of mature larva triangular, with many setae about as long as those of scoli. Prothoracic shield with three raised areas on each side containing many setae.

Pupa. Mottled brown due to tiny light or whitish areas, some dark brown areas, and many tiny brown striations. Some individuals are slightly darker due to larger tiny brown areas. Darker brown mottled patches occur as follows: crossing wing from near end of cell to tornus; on costa near apex; on dorsal edges of flanges of front wing base; on anterior edge of each side of prothoracic tergum; on abdomen two subdorsal spots on each segment, placed near posterior segment and positioned between the more anterior "tubercles"; near base of hindwing; near tornus of hindwing extending dorsally over the segment; on base of eclosion flap. Anterior half of dorsal tubercles brown, posterior half light. Wing cases with narrow brown striations parallel to veins in distal half of wing. Antenna shafts with many and legs with few narrow twinned whitish bands between segments. There are seven equally spaced brown lines on ventral of abdominal segments posterior to wingtips, the dorsalmost lines running through spiracles; reduced to five in some individuals and all very weak in other individuals. There are up to seven postmedian and up to eight marginal tiny whitish wing spots.

Shape as in *P. tharos*. Meso- and metathorax with two raised bumps ("tubercles") subdorsally. Abdominal segments 1-7 with three tubercles, one dorsally and two subdorsally, those of segment 1 weak. Abdominal segment 8 usually with a trace of one anterior dorsal tubercle. Cremaster with a depressed area near crochets (Fig. 2), a slit, and two ventral tubercles near anterior segment, which are circular and raised above the surface about their diameter or slightly greater (longer than dorsal tubercles). Often a black dorsal spot occurs next to crochets. There is a ventral sex mark just behind segment 8 (Fig. 2) which is a small slit bordered by two hemispherical raised areas in males, a slightly longer slit without raised areas in females. Abdominal segment 8 and 9 fused, with a weak dorsal intersegmental groove.

COMPARISON WITH OTHER PHYCIODES

Seasonal and individual variation is considerable in published descriptions (Davenport & Dethier, 1937; Edwards, 1889) but some differences can be noted. *P. tharos* eggs have slightly fewer ribs than other species. First instar prothoracic shield is unsclerotized in *P. orseis*, partly sclerotized in most other species. Larval setal pattern is very similar or identical in all *Phyciodes*. Mature larval color of *P. orseis* is most similar to that of *P.*

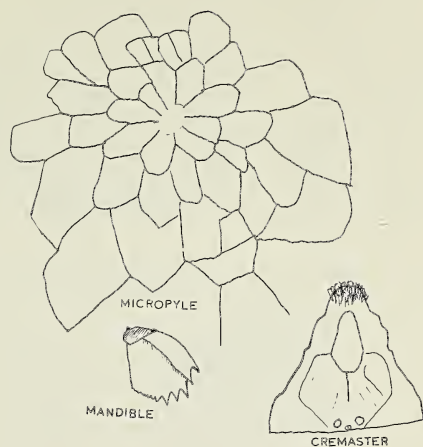


Fig. 2.—Micropyle, cremaster (dorsal view), and right mandible of mature larva (posterior view) of *P. orseis*. Circles on cremaster represent cuticular processes.

mylitta and *P. campestris*, which are rather black, and differs from the brownish, olivaceous, or yellowish brown colors of other published species. The larval color pattern of *P. orseis* differs from *P. phaon* and *P. tharos* (which are fairly similar to each other in body and head pattern) and from *P. texana* which all have light stripes through subdorsal scoli. Body pattern of *P. orseis* is similar to some *P. picta* and *P. campestris* larvae but they also have a light stripe through subdorsal scoli. Only *P. orseis*, *P. mylitta*, and some *P. campestris* larvae have lighter line next to mid-dorsal black line. Body pattern of *P. orseis* is most similar to that of *P. mylitta*. The *P. orseis* head pattern is unlike the whiter heads of *P. phaon* and *tharos*, and unlike the uniformly dark heads of *P. texana*, but it resembles the heads of *P. picta*, *campestris*, and *mylitta*. These three species apparently lack the lower circular spot of *P. orseis*, however (or it was missed by the authors?). Pupae are all similar and are variable in color. *P. orseis* pupae are darker than those of *P. phaon* and *picta* and some *P. campestris* and *P. tharos*. Pupal color of *P. mylitta* is fairly similar to *P. orseis*. In summary, early stages are most similar to *P. mylitta*, which shares with *orseis* the very dark dorsal larval color of later instars, the twinned dorsal whitish line, and most other characteristics.

TAXONOMIC RELATIONSHIP

Although *P. orseis* has often been confused with *P. campestris* in the past, it is actually most closely related to *mylitta* (or *pallida*) in early stages, some aspects of wing pattern, food-plant, and adult behavior. *P. orseis* is a distinct species, as it is sympatric with *P. campestris* and *P. mylitta* near Glenbrook and in the rest of its range (its range is within the range of both latter species) and does not interbreed with them; the reared adults differed from wild *P. orseis* adults only in slightly smaller size.

P. orseis and *P. campestris* show parallel color variation. In northern California and southern Oregon *P. orseis orseis* and *P. campestris campestris* are both dark, and in the Sierra Nevada *P. orseis* subspecies (being described by David L. Bauer) and *P. campestris montana* are light in color. These two *orseis* forms intergrade in the Mt. Shasta area (David Bauer, oral communication), and both *campestris* forms intergrade and often occur in the same meadow. *P. orseis* differs from *campestris* in having falcate forewings, and in having a more distinct pattern of lines on the underside of the hindwing, which resembles *P. mylitta* in *P. orseis orseis*, and is rather uniform pale yellowish in color in *P. orseis* from the Sierra Nevada. *P. campestris* has the hindwing underside without a silvery median band (except in some females), and the lines are usually weakly developed especially distally.

Only *P. orseis* and *P. mylitta* are known to feed on thistle. Other Phyciodes feed on other Compositae, Verbenaceae, or Acanthaceae.

Only *P. orseis*, *P. pallida*, and *P. "batesii"* are single-brooded (May-June), except that *P. campestris* and *P. tharos* are single brooded in the northern part of their range.

The adult behavior of *P. orseis* is most like *P. mylitta* and *P. pallida*. Butterflies use two methods to locate mates (Scott, 1973): perching, in which males sit at characteristic sites and dart out at passing objects in search of females, which fly to these sites to mate, and patrolling, in which males fly almost constantly in search of females. *P. orseis orseis* in the Siskiyou Mountains, California, and *P. orseis* ssp. near Glenbrook have nearly identical behavior and strangely even look alike in flight. Males perch on small shrubs or occasionally on the ground in small depressions between tall riparian vegetation and a hillside. Siskiyou Mts. males usually perch on shrubs

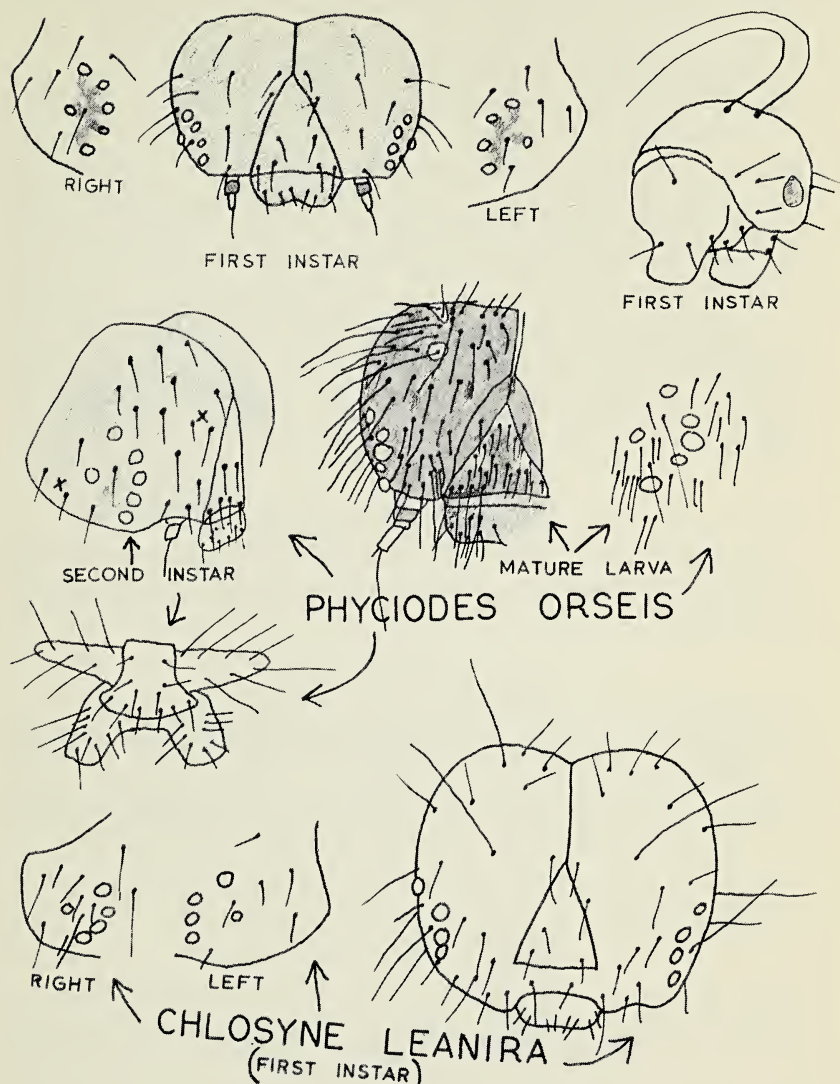


Fig. 3.—Setal pattern of heads of *P. orseis* (and *Chlosyne leanira fulvia* for comparison) (including details of ocellar setae), and oblique or posterior view of terminal segment of *P. orseis* larvae. In second instar *P. orseis* head, the two X's represent setae which are present on some other individuals.

while Sierra Nevada males often perch on or near the ground. Males perch throughout the day, and a copulating pair was found at 1415 (24-hr. ST) at one of these sites near Glenbrook. Only three other *Phyciodes* are known to be perching species. *P. mylitta* perches throughout the day in the same sites near Glenbrook and in small gullies at other localities. *P. pallida* perches all day in small gullies and occasionally patrols on hill-sides and ridges. *P. texana* perches in gullies and stream beds. *P. campestris*, *P. tharos*, *picta*, *phaon*, and *vesta* are all patrolling species; males patrol all day near the ground in fairly flat areas near the larval host, such as meadows, grassy swales, etc.

Actually, *P. orseis* may prove to be more closely related to the allopatric *P. pallida* than to *mylitta*, and may even be a subspecies of *P. pallida*. *P. orseis* from the Sierras is more similar to *P. pallida* than to *P. mylitta* in appearance. The life history of *P. pallida* is unknown, but it probably also feeds on thistle.

ACKNOWLEDGMENTS

I thank Rev. David L. Bauer, who showed me how to recognize *P. orseis* and directed me to localities mentioned in this study.

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BOOK REVIEW

Annotated Checklist of the Butterflies of Illinois, by Roderick R. Irwin and John C. Downey. May 1973. Urbana, Ill.: Ill. Nat. Hist. Surv. Biol. Notes No. 81: 1-60.

This is the first work to treat the entire butterfly fauna of Illinois since 1880, and as such its publication is welcome. It is more than an annotated checklist in the usual systematic sense, for as the authors state in their introduction, "This report is a distributional study, not a manual for the identification of Illinois butterflies."

Each species is listed first by scientific name, author, and common name. A skeleton synonymy then lists a citation of the original description and type-locality, references to some important synonyms, names cited in error or in other combinations, and also references to works by Holland, Klots, dos Passos, and Worthington's 1880 list of the diurnal Lepidoptera of Illinois. Following the synonymy is either a reference to one of the maps, or a list of known localities if the species is known from six or fewer Illinois localities. (The maps are conveniently placed together at the end of the paper.) Concluding each species account, a statement is given which may include such topics as earliest and latest dates of capture (of adults), number of broods, larval foodplants, or a statement about the known or suspected distribution in Illinois. These concluding statements vary from one sentence to nearly a full column, giving very uneven treatments to different species.

The species are listed in the order of the dos Passos checklist of Nearctic Rhopalocera. Species believed to be validly recorded from Illinois are listed first, followed by 24 species of possible occurrence and then by a short mention of 4 erroneous records. Valid records are available for 150 species, distributed by families as follows: Hesperidae 55, Papilionidae 6, Pieridae 14, Riodinidae 1, Lycaenidae 27, Liphiridae 1, Libytheidae 1, Nymphalidae 35, Danaidae 2, and Satyridae 8.

Application of subspecific names, when available and established in the literature, is apparently random. A polytypic species having relatively distinctive and widely-accepted subspecies in the Nearctic area may be listed only by the binomial, no reference even being listed in the synonymy to any subspecific names. Other species are listed as trinomials without comment. This contrasts with the relatively lengthy systematic discussions accorded to *Limenitis arthemis*, *Lethe eurydice*, and *L. appalachia*. Even among the Lycaenidae (Downey's specialty) the treatment is uneven.

Form names are also inconsistently used. While these infrasubspecific names have no formal place in nomenclature, if they are listed for some species (e.g., *Poanes hobomok*, *Eurytides marcellus*) they should be listed for others (e.g., *Papilio glaucus*, *Callophrys gryneus*).

Three black-and-white plates illustrating 41 specimens of 34 species from Illinois follow the literature cited. Some specimens might have profitably been re-spread before the photographs were made, or omitted. Several of the rarer skippers are among the species figured.

The distributional study is presented primarily as a series of spot maps prepared on identical base maps showing Illinois counties. Records are based on institutional and private collections, and the literature. Localities for specimens examined are not distinguished from those based on literature records. Some literature records appear to be missing, for example *Papilio ajax ajax* form *pseudoamericanus* Brown, 1942 (Ent. News, 53: 291),

described from Troy, Madison Co., Illinois. The many season summaries of the Lepidopterists' Society, containing a number of Illinois records, are rarely mentioned.

The maps are a valuable compilation, and the authors are to be commended for taking the time and trouble to prepare them. I am glad to see that the dots represent actual collection sites and not merely county records. Although dots on maps are nice, they all too often represent the activities of the collectors rather than the organisms being studied. *Phyciodes tharos*, for instance, is surely one of the most common and widespread butterflies in Illinois, but records are available from less than half the counties. Although 98 species are mapped and a brief section mentions several ecologic areas within Illinois (including citation of several floral references), virtually no attempt has been made to deduce any distributional patterns exhibited in the state. This reviewer sees the authors' failure to go beyond merely plotting the localities as a major shortcoming of the paper. Also, the reader cannot determine the distribution of most of the species outside of Illinois. Although political boundaries are convenient in terms of delimiting the size of a study area, they are not important to the butterflies. We need to keep this in mind when making studies such as this.

Unevenness in coverage and format tend to mar the quality of this paper, but it is a step in the right direction and should be welcomed as an addition to our knowledge of Illinois butterflies. I hope that the authors fulfill a promise made on page 4: "A more comprehensive account of the history of butterfly collecting in Illinois and of the principal collectors in the state will be published elsewhere as an outgrowth of this study." I hope they are able to expand their ecological treatment as well, for if we are to be truly concerned about the existence of these organisms in relation to their environment, we need to have this information available now, before habitats and the butterfly fauna are further altered. Illinois has an area of about 56,400 square miles, and although the extremes in elevation differ only by about 700 feet, Vestal's 1931 floral study of the state recognized 9 vegetational divisions. Interestingly, certain groups of terrestrial vertebrates show faunal divisions in Illinois very similar to the floral divisions of Vestal. As most butterflies depend upon plants for food, it would be interesting to determine whether their distributional patterns match the vegetational ones. Certainly, the last word on Illinois butterflies has not yet reached the tongues of the Lepidopterists who study them.

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NOTICES

A usual thing for this day and age: An inevitable price rise. However, we are trying a very minor change even though many prices now days have doubled or tripled. Just remember that there are no employees of the Foundation or the Journal who receive a single cent for their services. All funds received go one hundred percent into the publication so that that there may be a first class medium for the public analysis of research work on the Lepidoptera. The new rates for volume 13 will be:

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EMMEL, T. C. and JOHN . F. EMMEL 1973.

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COVER ILLUSTRATION

Monoctenia (?) falernaria ♂ (Geometridae)

Living adult in natural resting pose , taken in late March 1966
Blackwood, S. Australia at U. V. light
by NOEL McFARLAND

THE JOURNAL OF RESEARCH ON THE LEPIDOPTERA

Volume 12

Number 4

December, 1973 (1974)

IN THIS ISSUE

- | | | |
|---|-----------------------------------|-----|
| Adult behavior and population biology of two
skippers mating in contrasting topographic
sites | James A. Scott | 181 |
| Acceptance of artificial diet by
<i>Megathymus streckeri</i> (Skinner) | M. A. Petterson and R. S. Wielgus | 197 |
| Some observations on the eggs of moths and certain
aspects of first instar larval behavior | Noel McFarland | 199 |
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check list (1972). Part I. | Juraj Paclt | 211 |
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Edwards 1862. | J. W. Tilden | 213 |
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of moths. | Charles L. Selman | 217 |
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Sierra Nevada | Arthur M. Shapiro | 231 |
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of Illinois by R. R. Irwin and J. C. Downey | R. S. Funk | 243 |





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